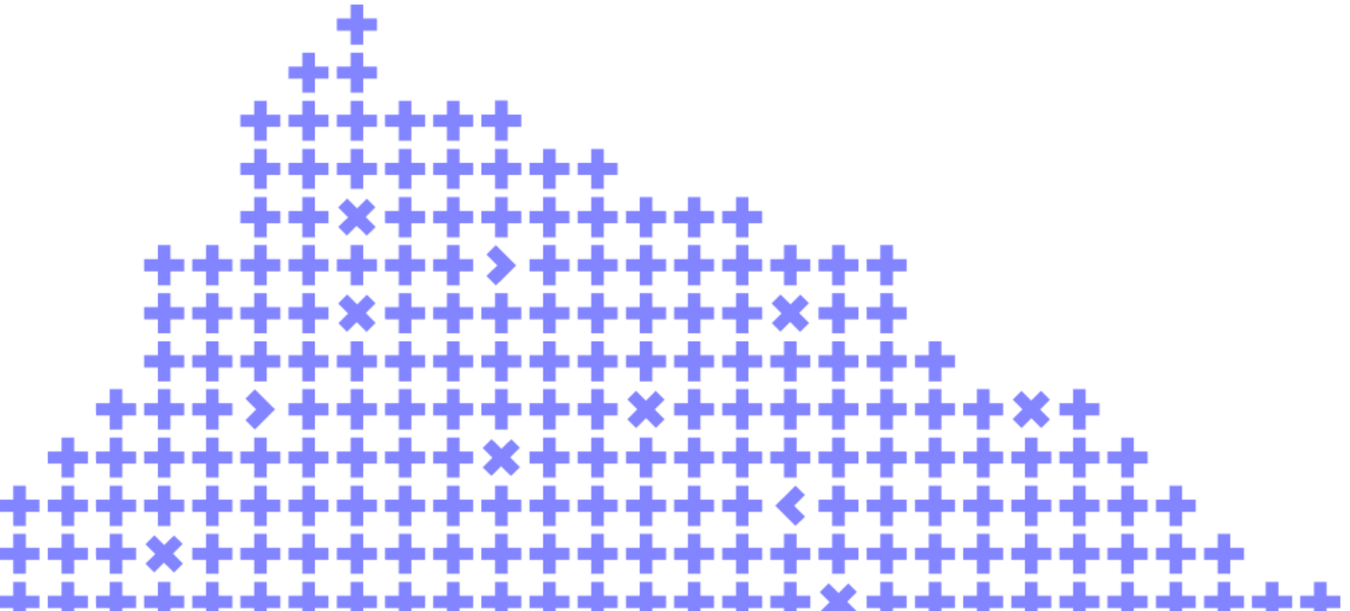
Microservices on C++, or why we made our own framework

Antony Polukhin



++ High Load Armenia

Co-organizer

Yandex

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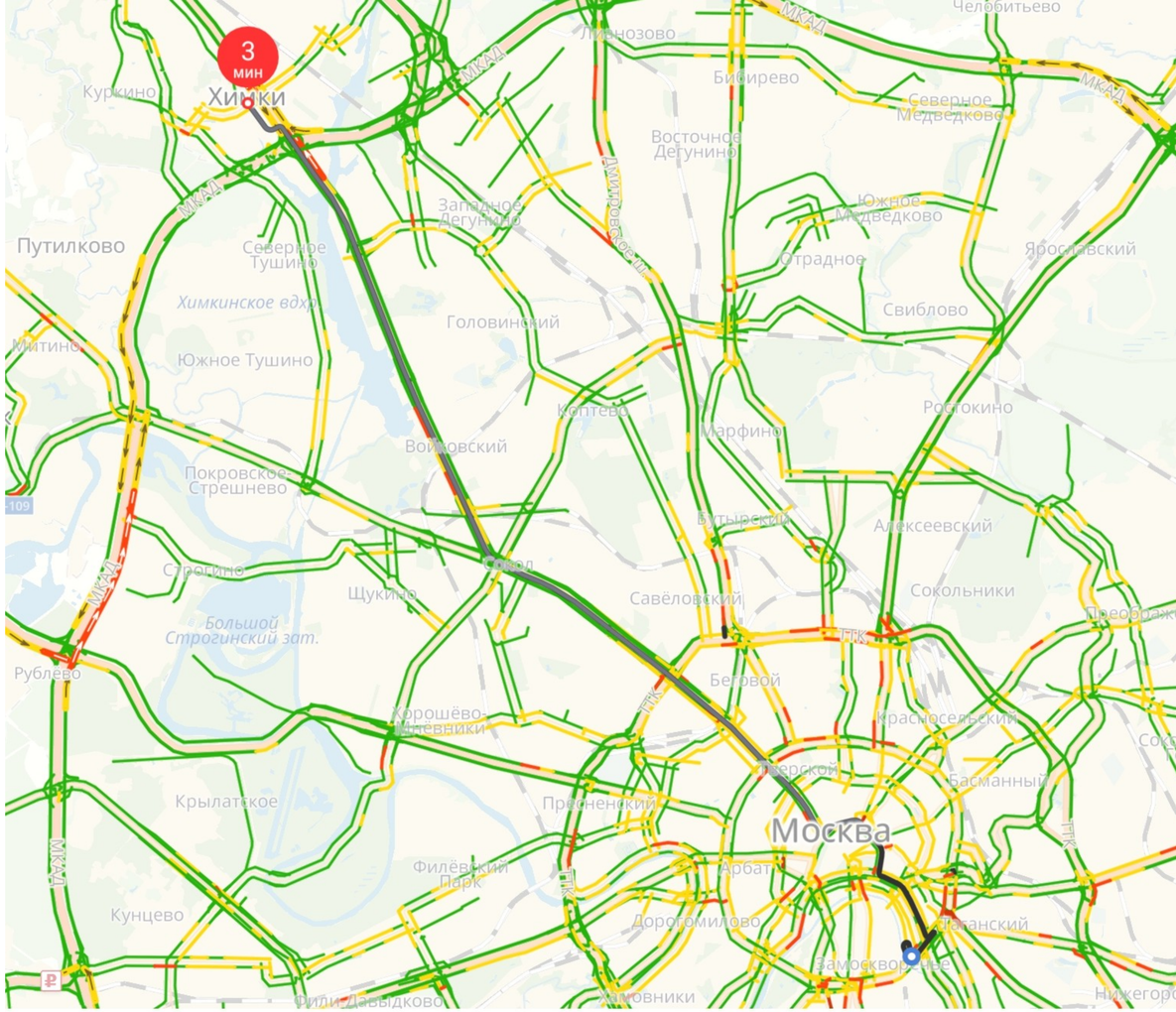

The Task

The Task — make everything better

The Task

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We need

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We need:

- Efficiency

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- Efficiency
- Simplicity of development

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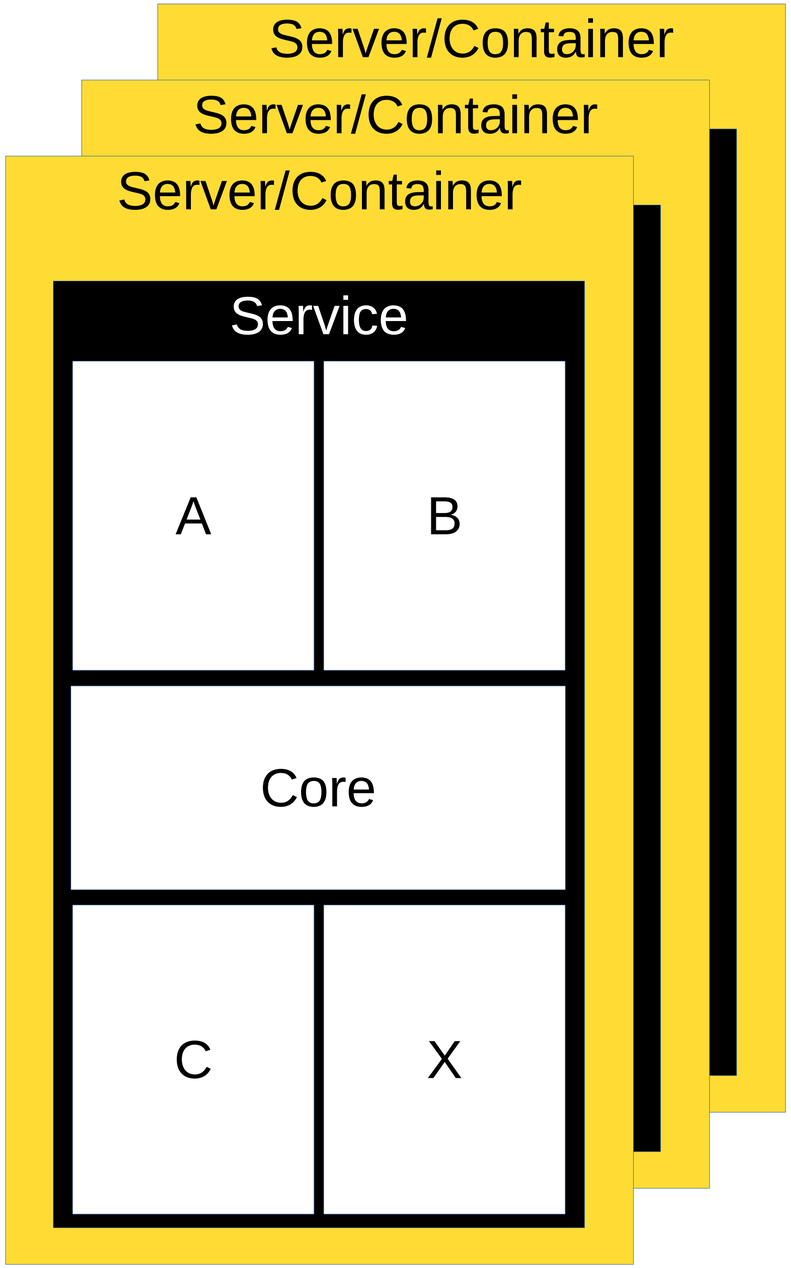
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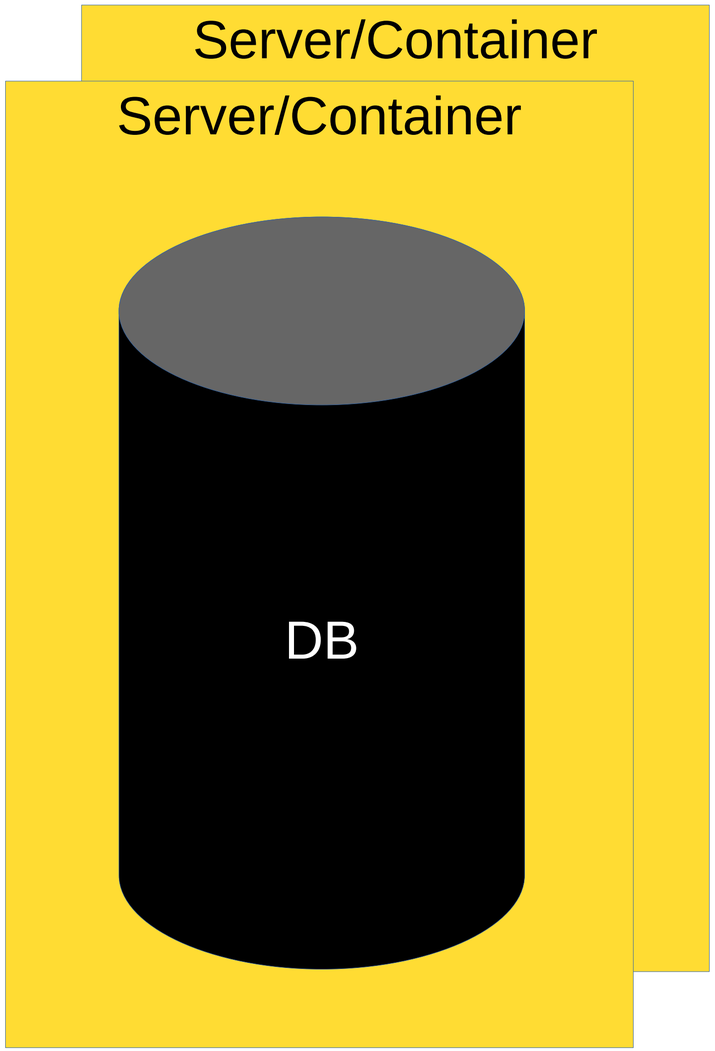
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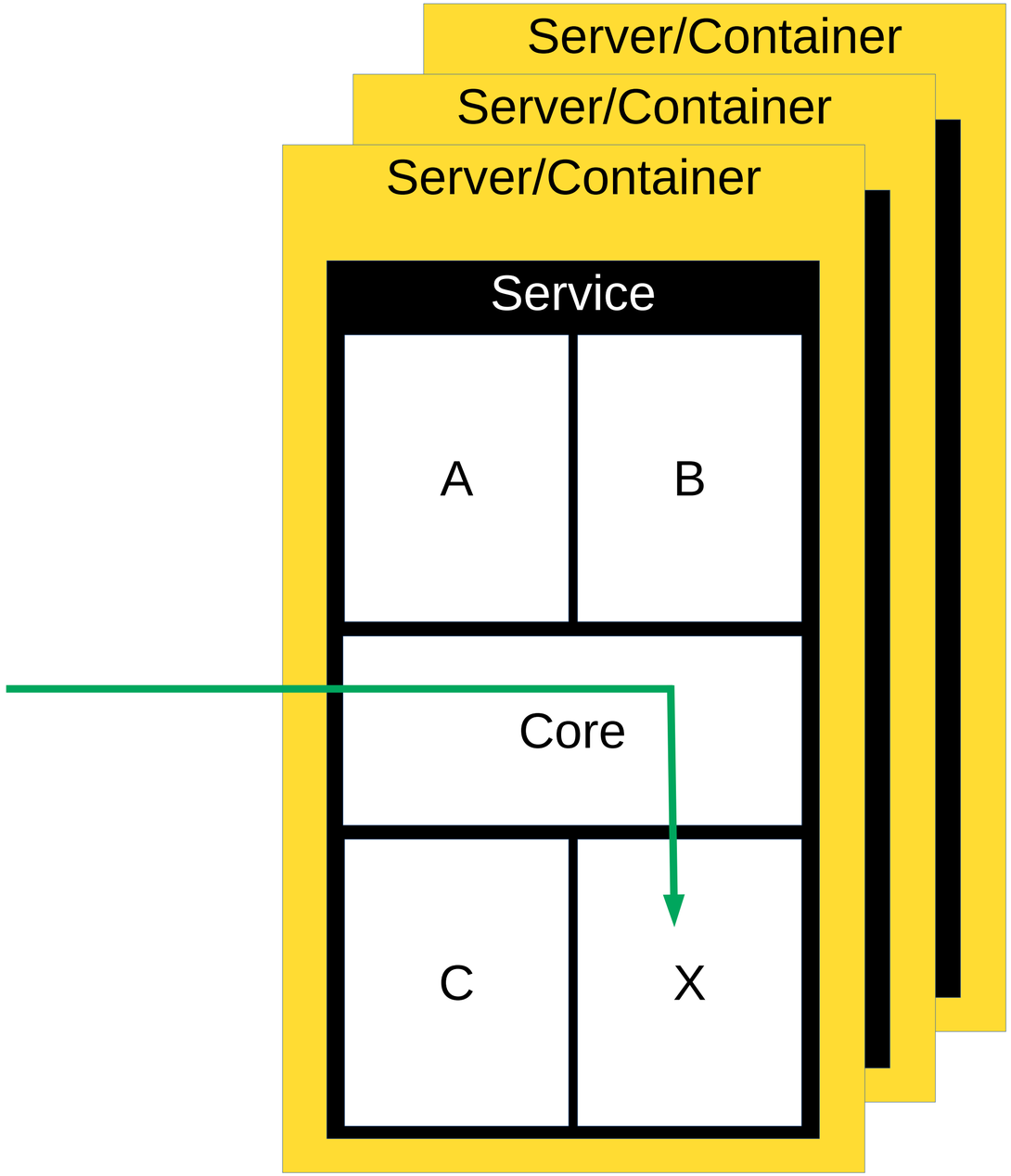
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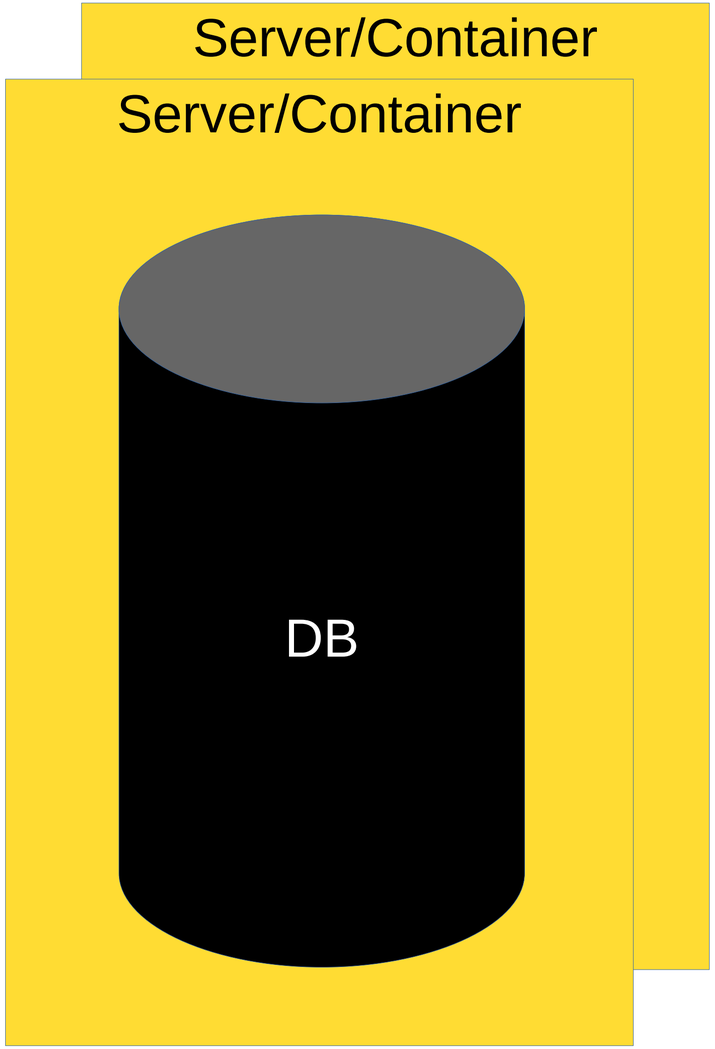
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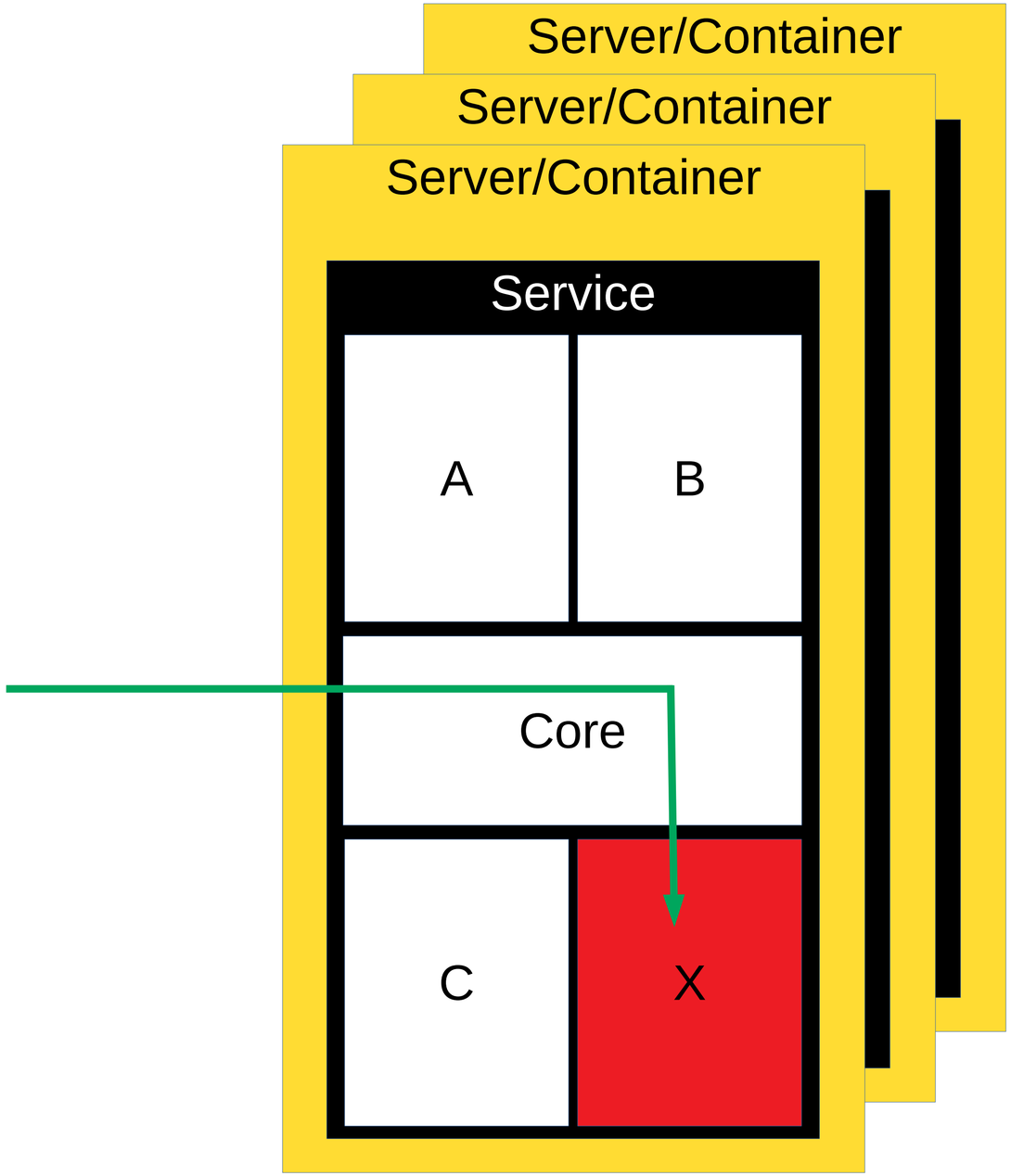
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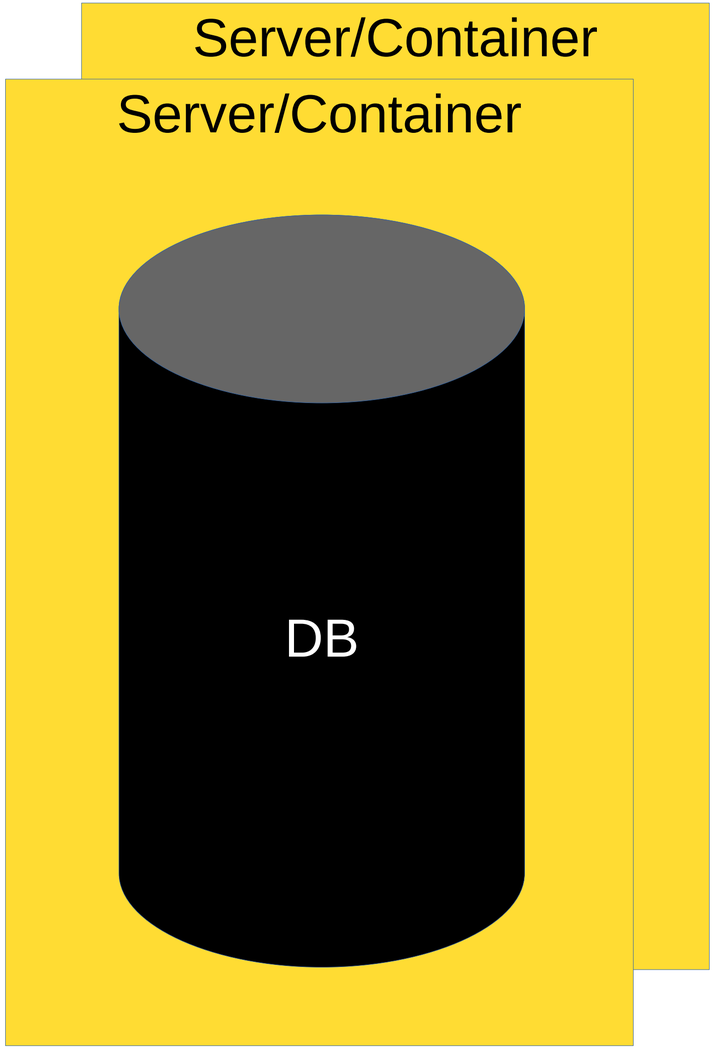
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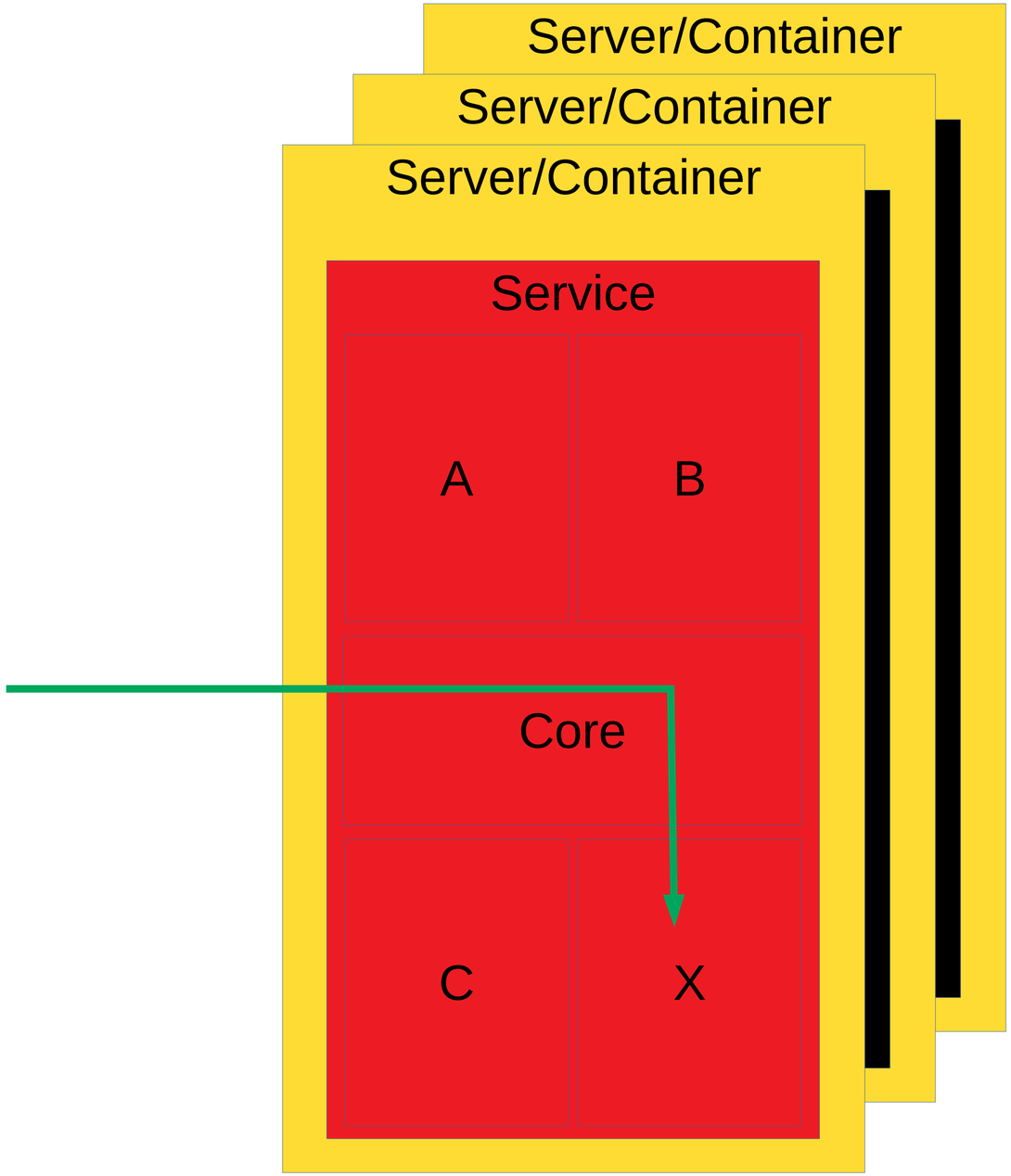
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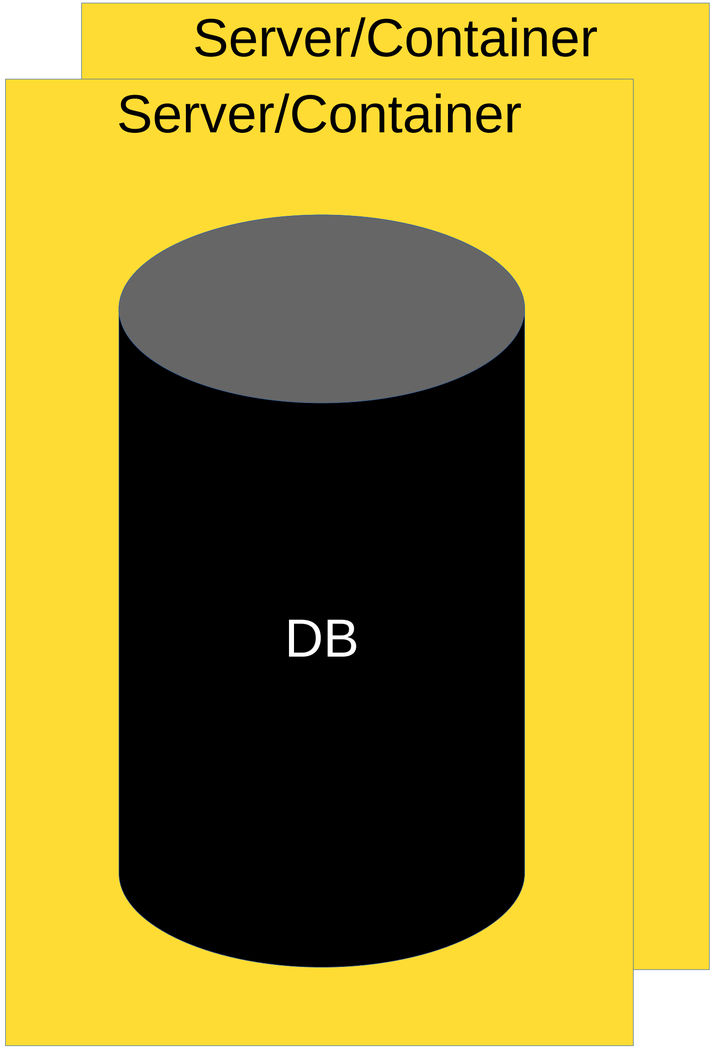
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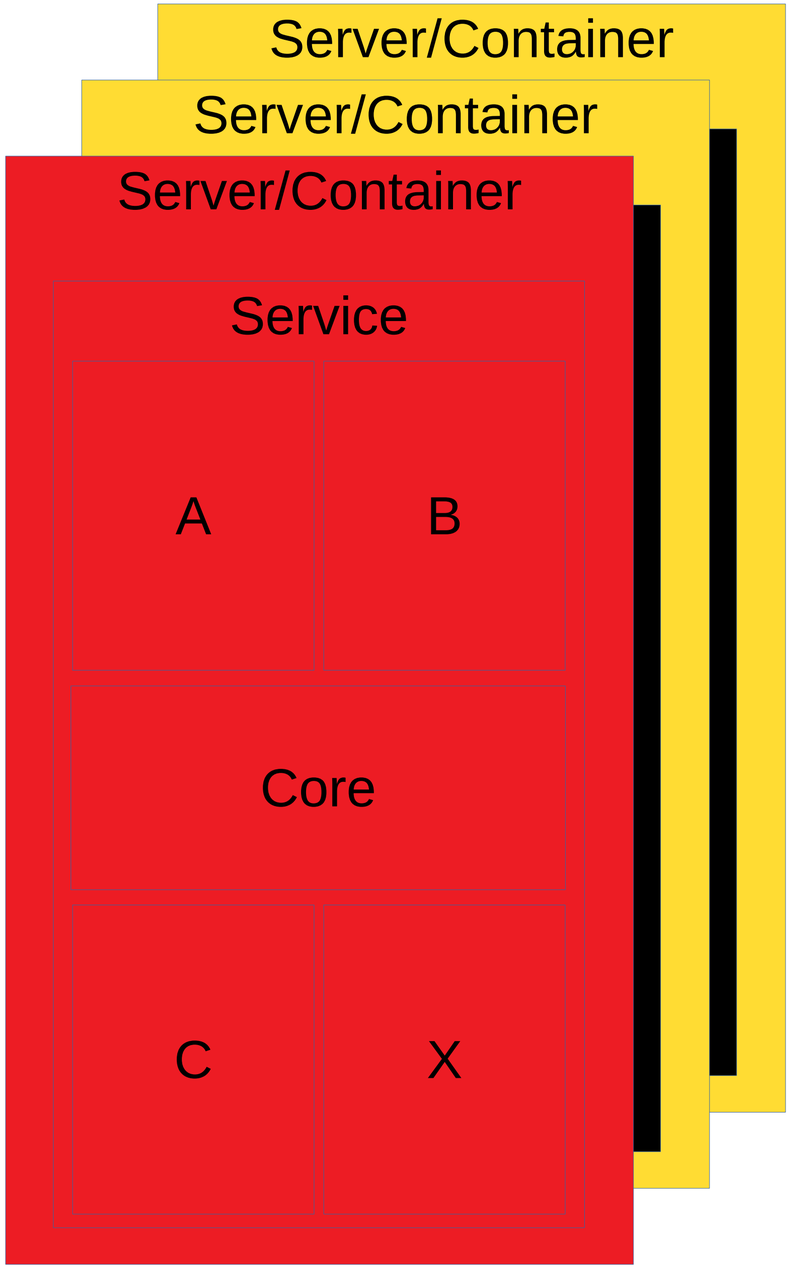
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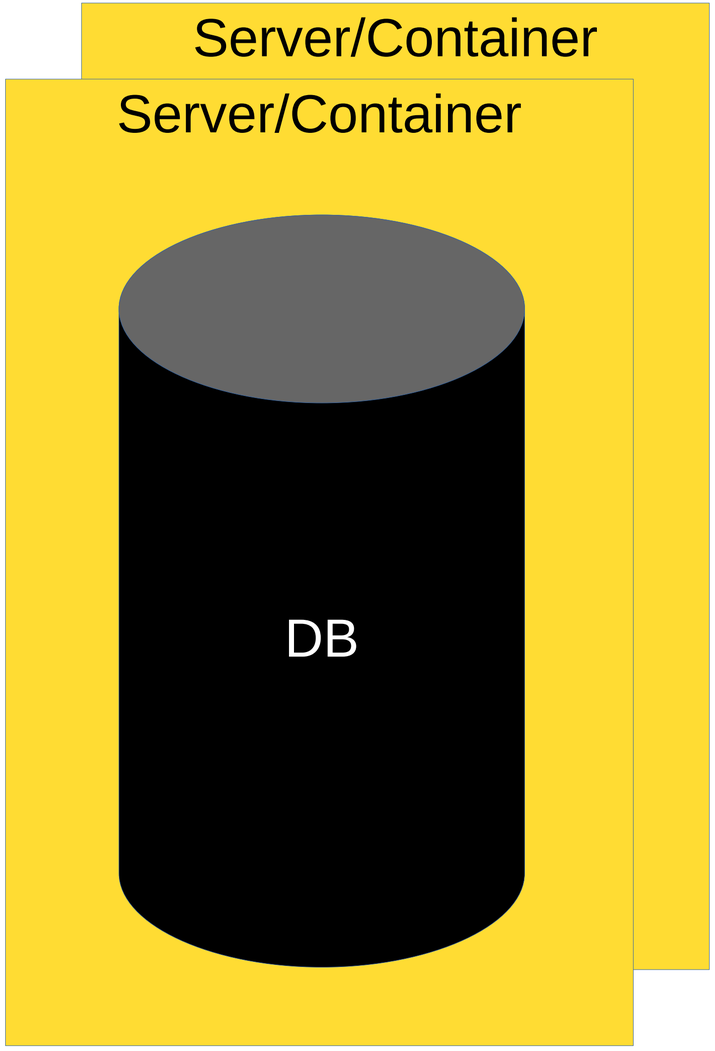
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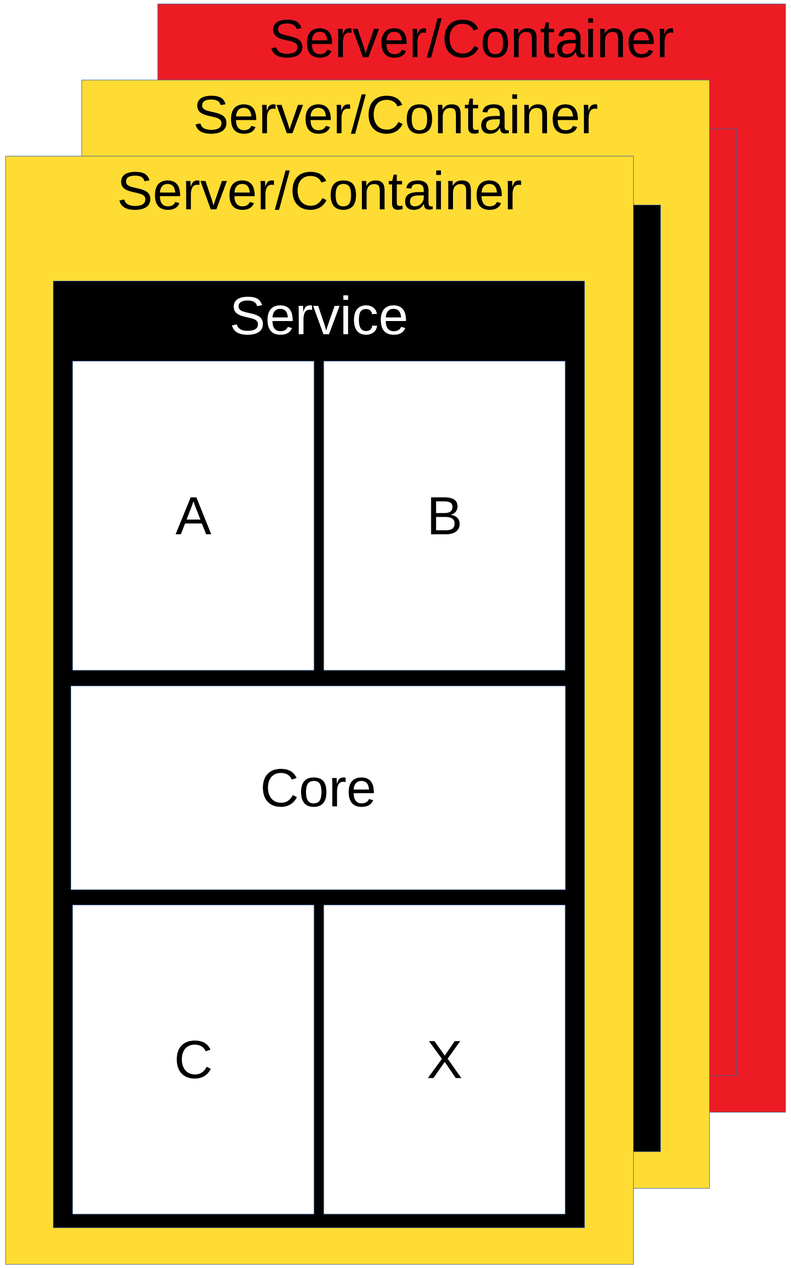
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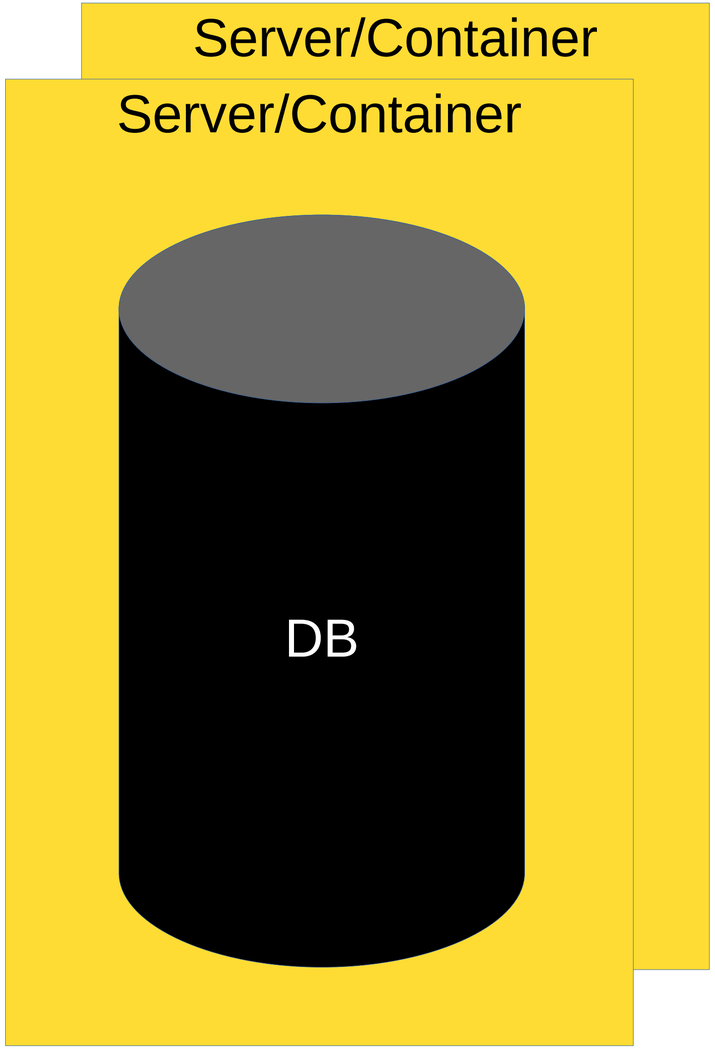
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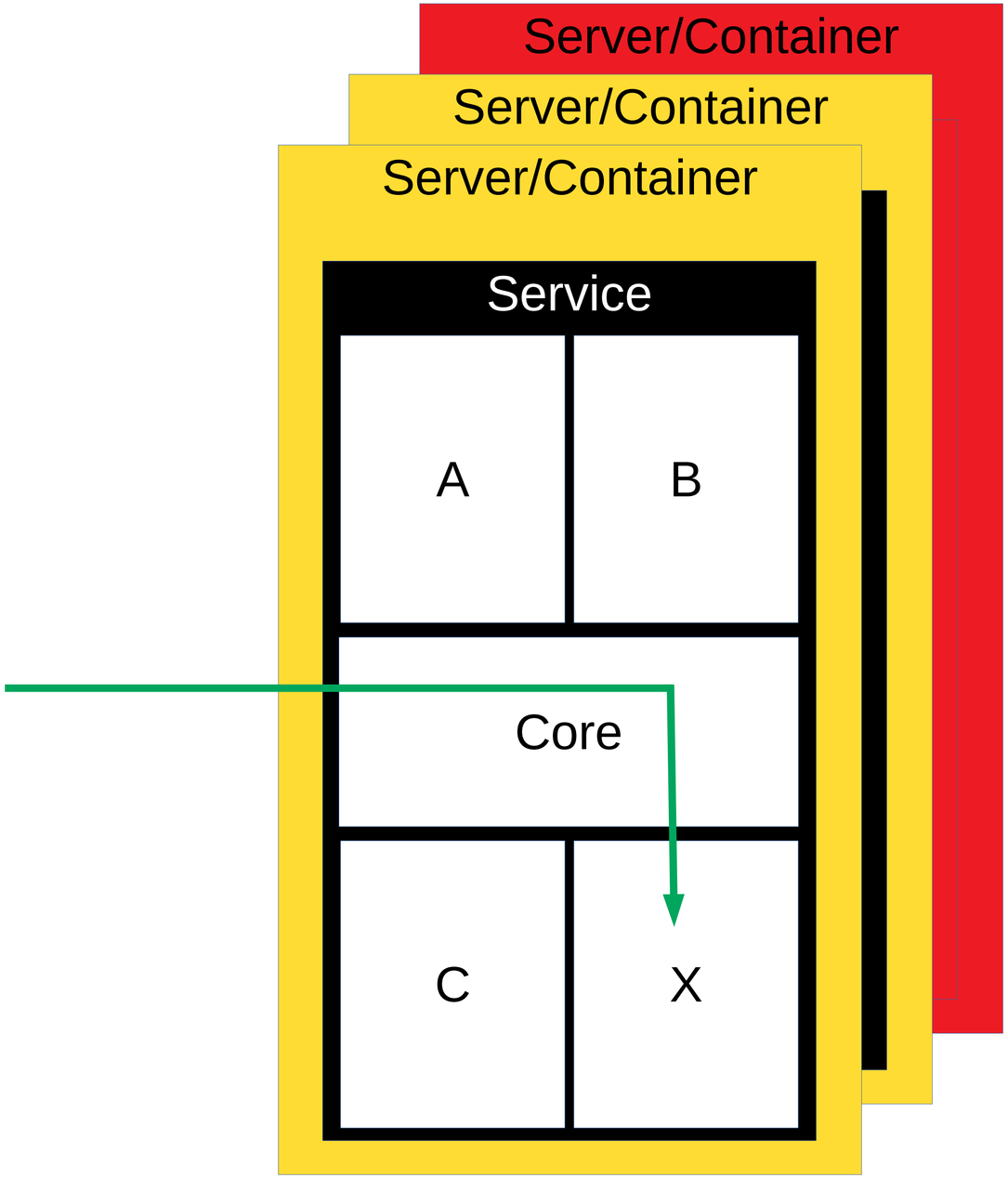
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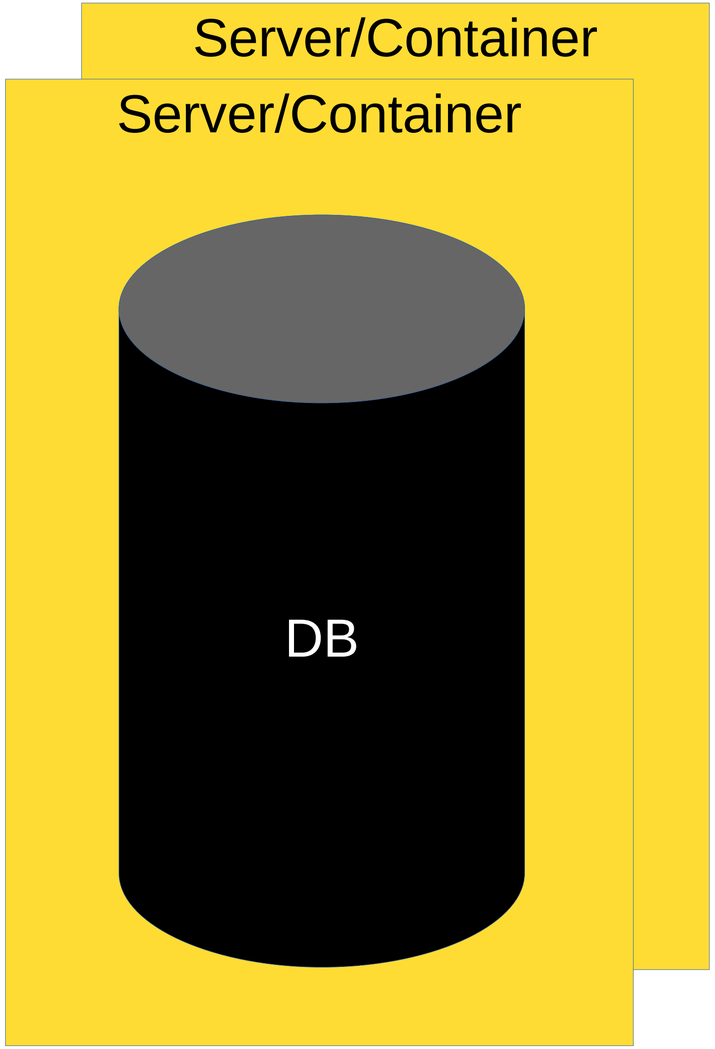
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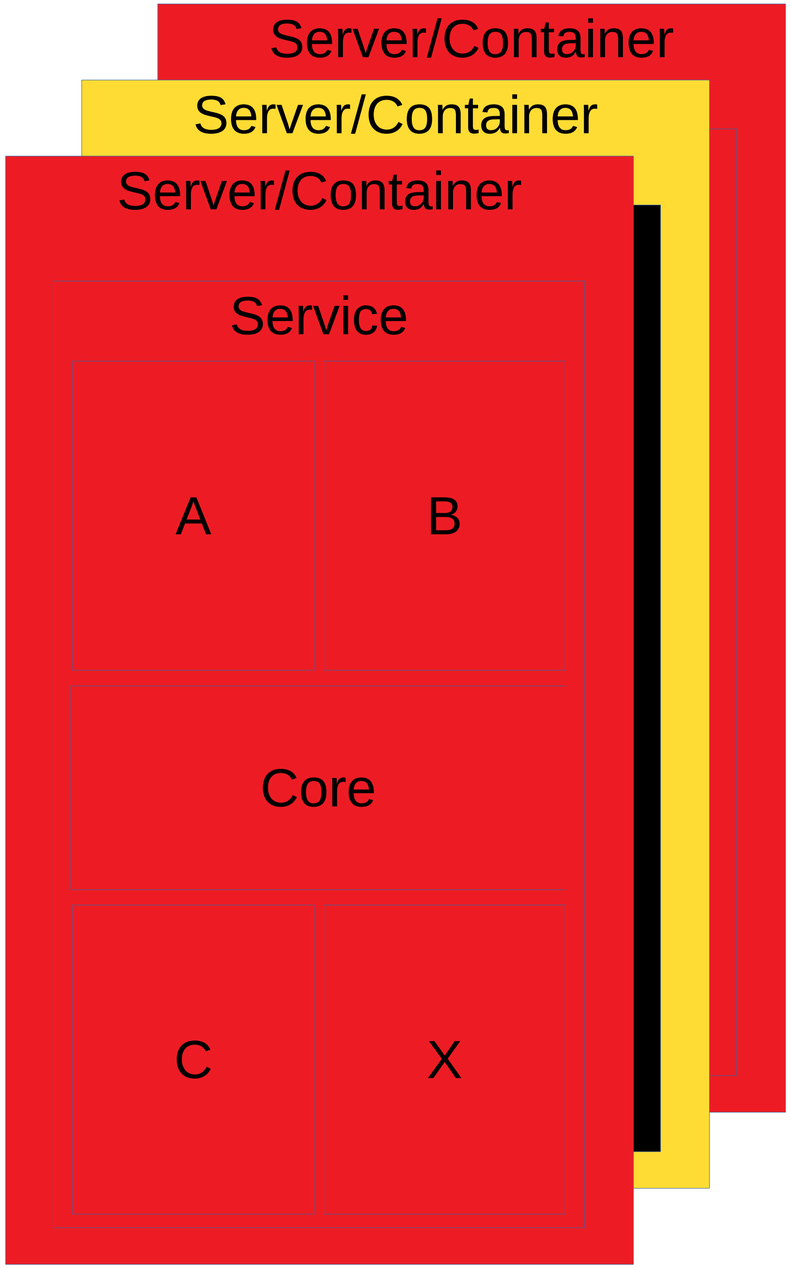
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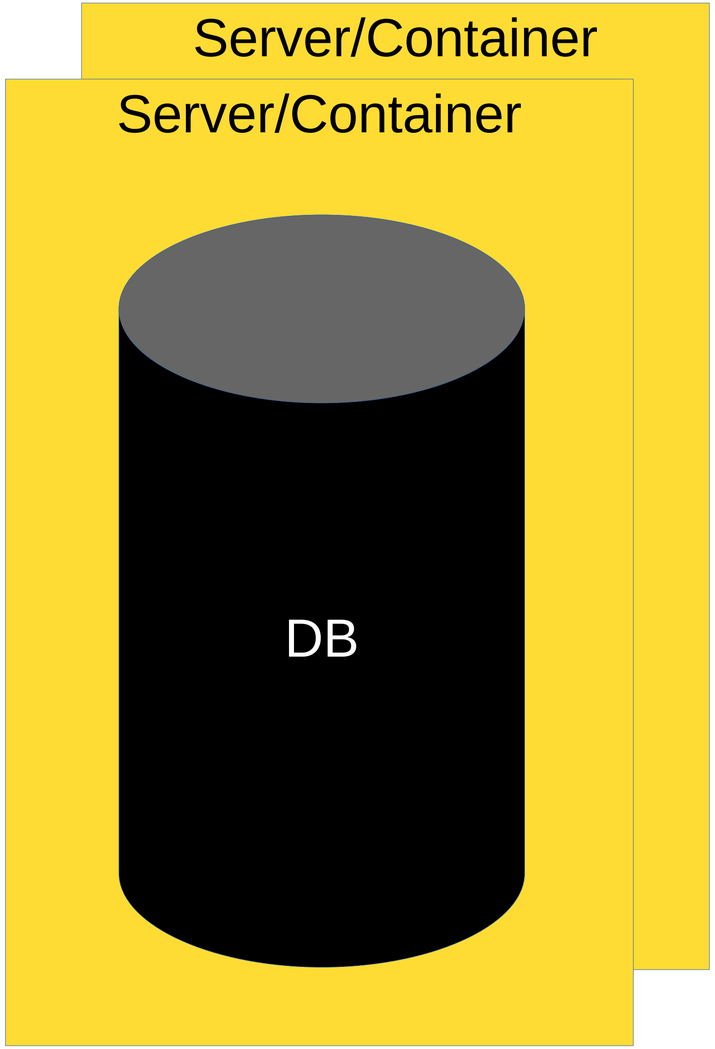
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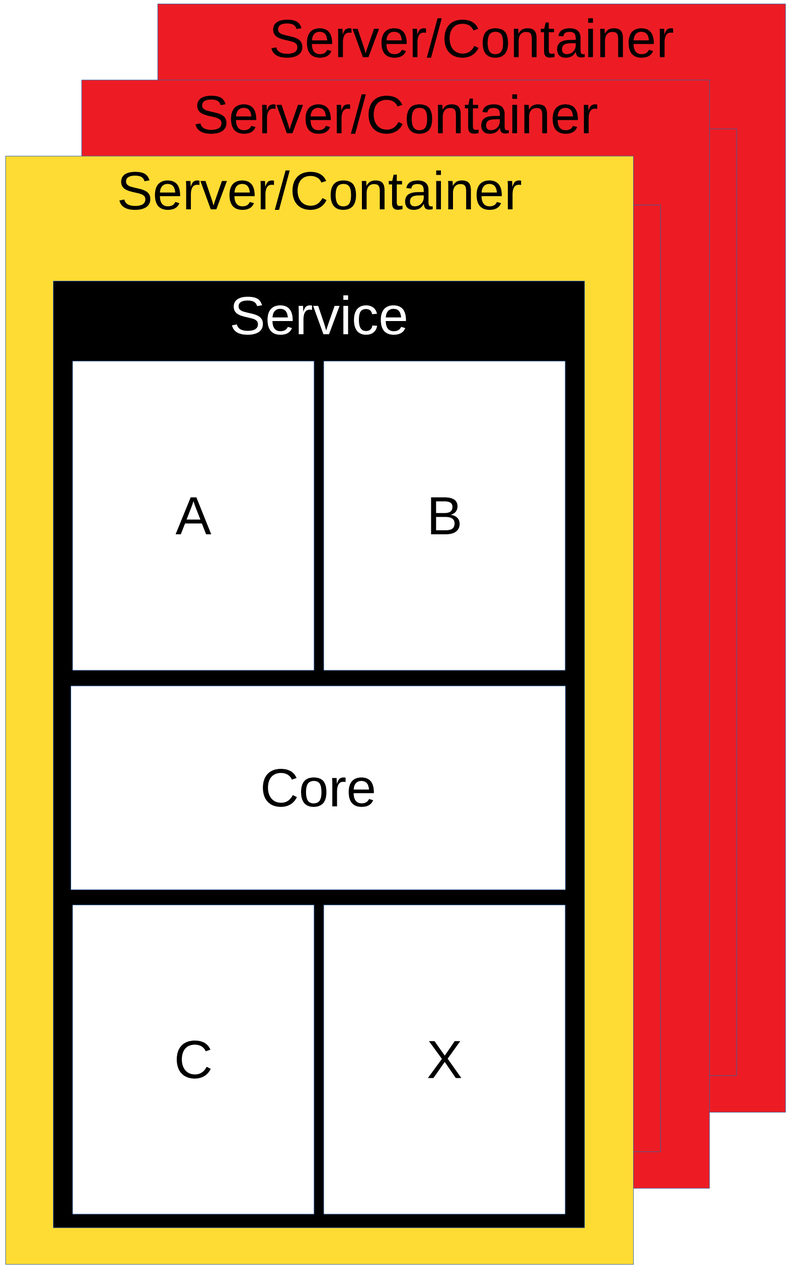
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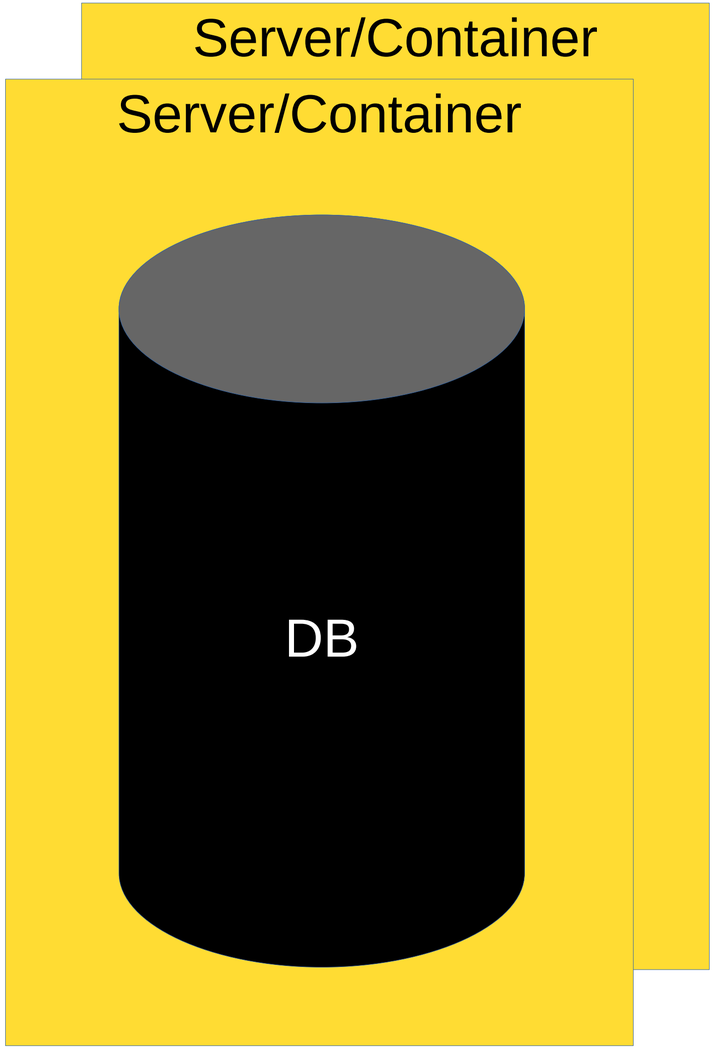
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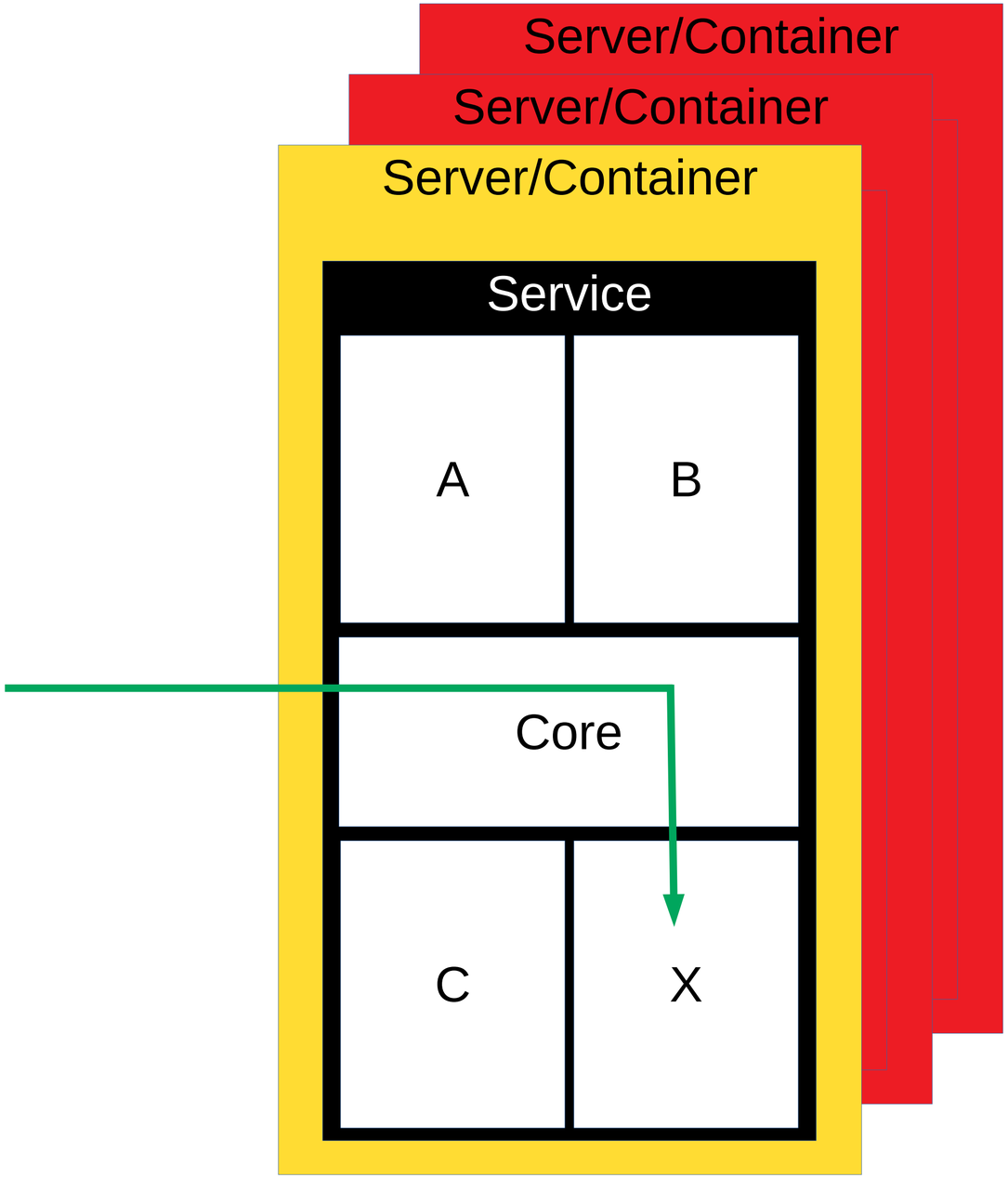
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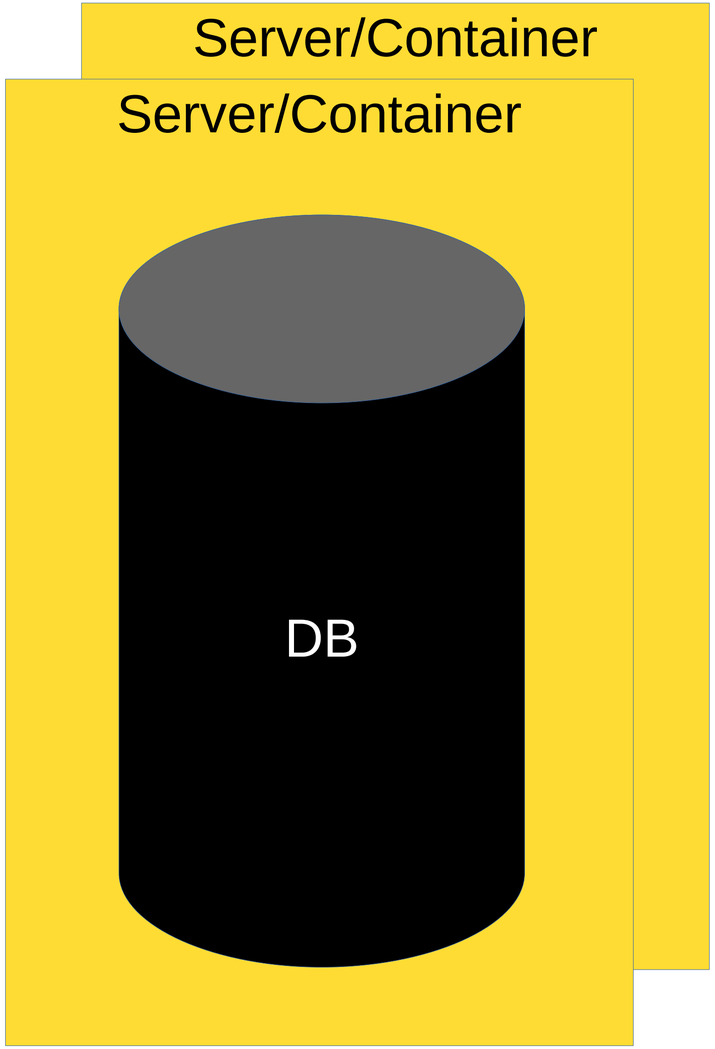
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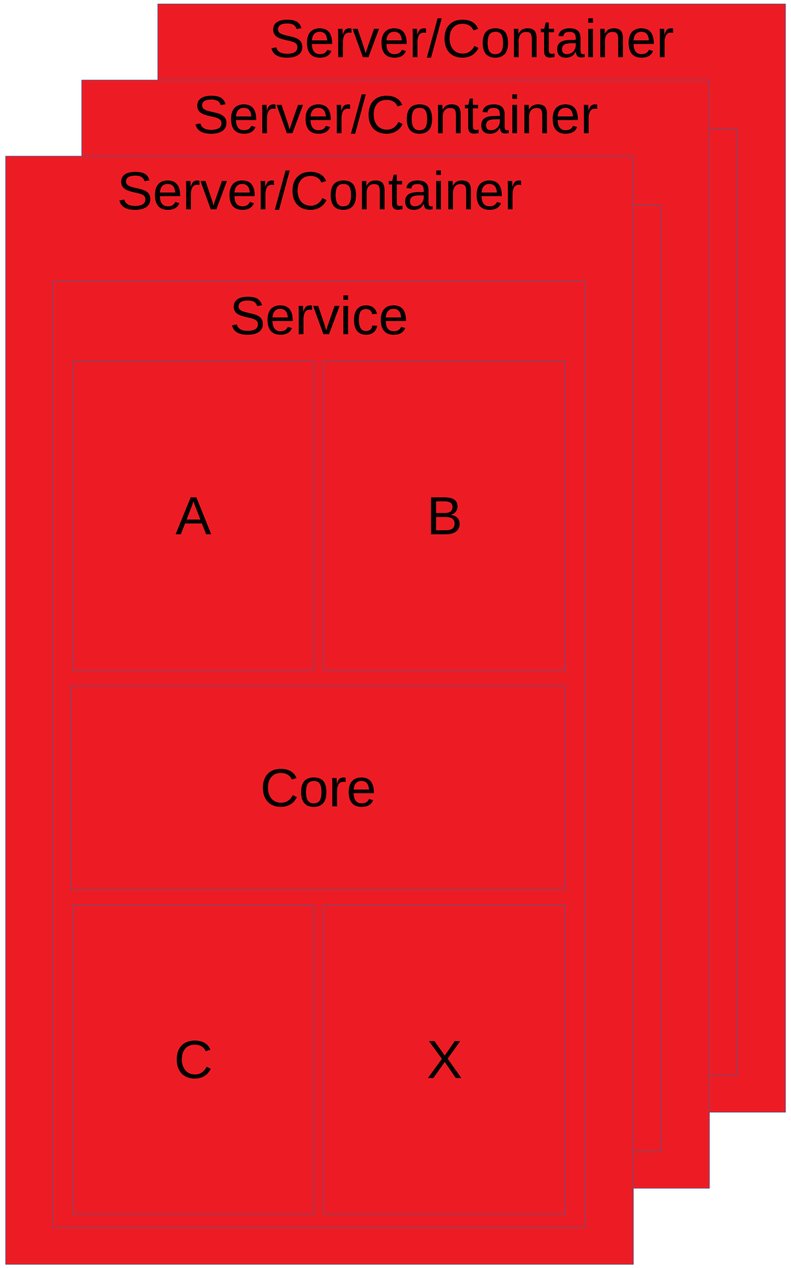
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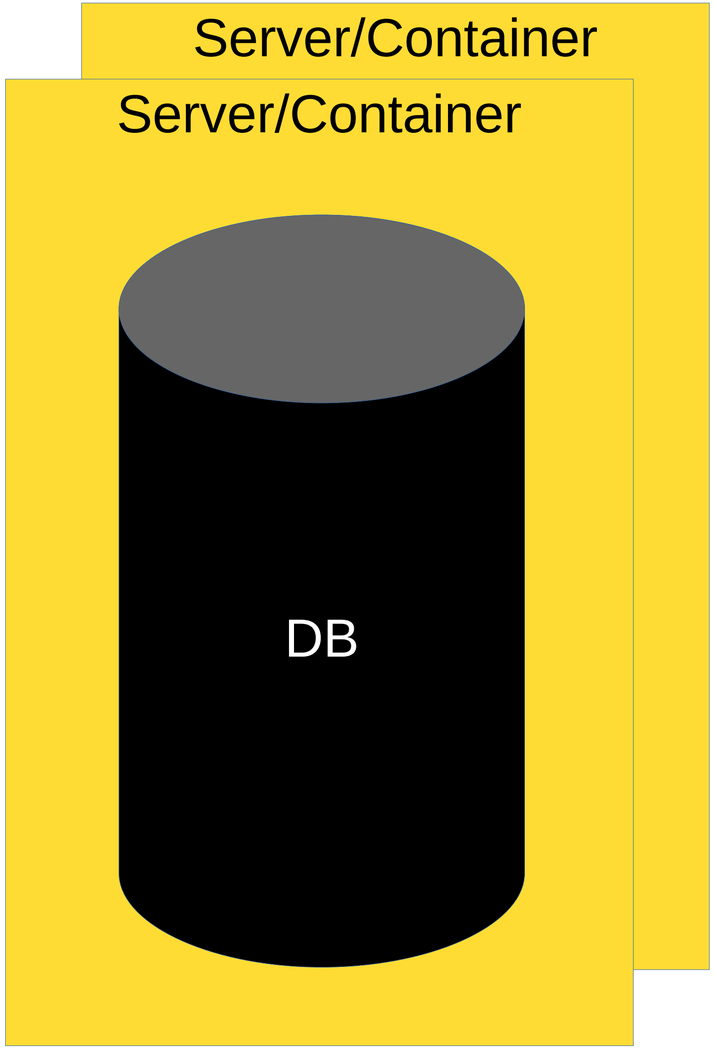
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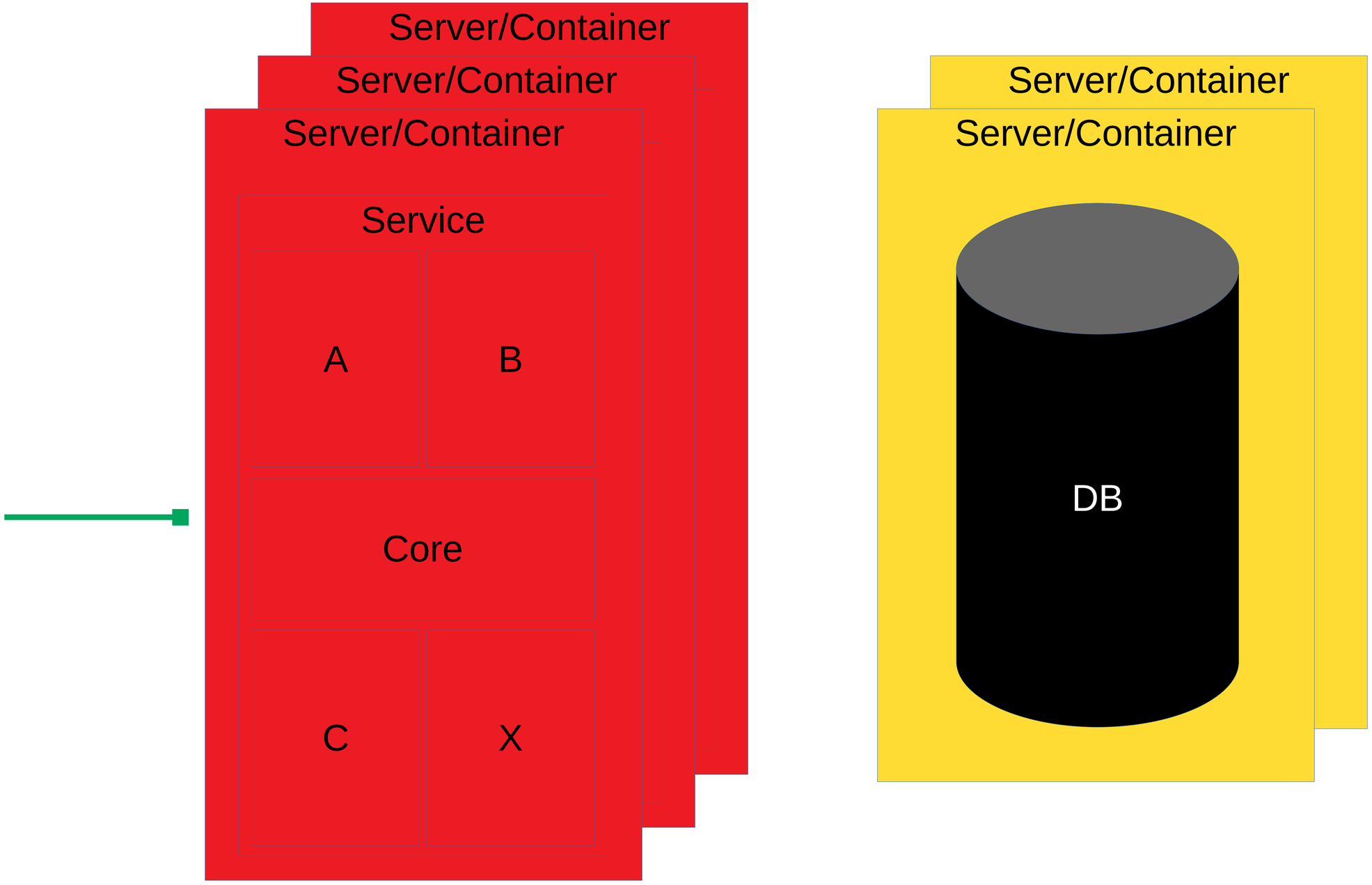
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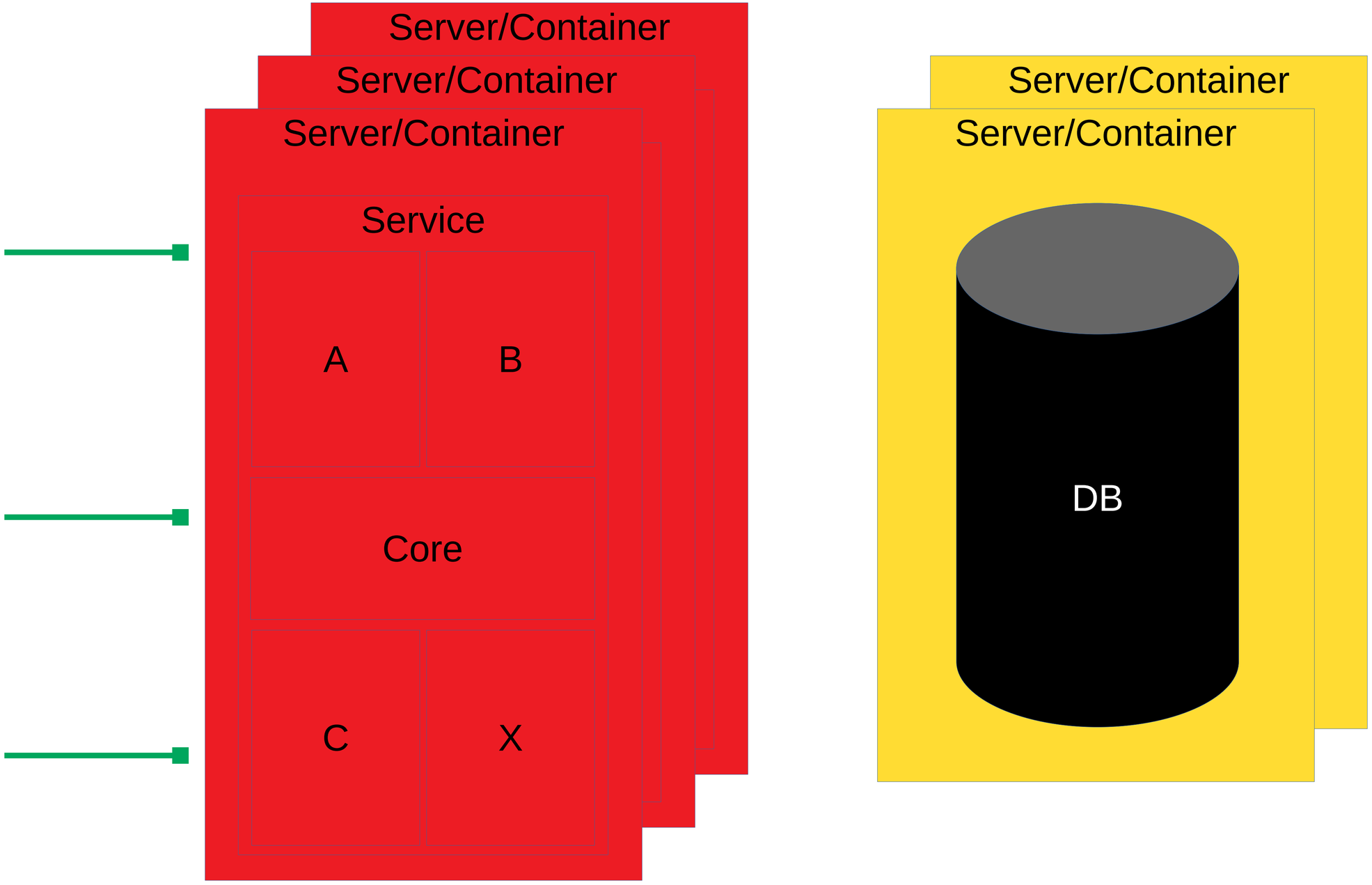
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Existing C++ frameworks:

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- Provoke callback hell

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Microservices:

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Existing C++ frameworks:

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Microservices:

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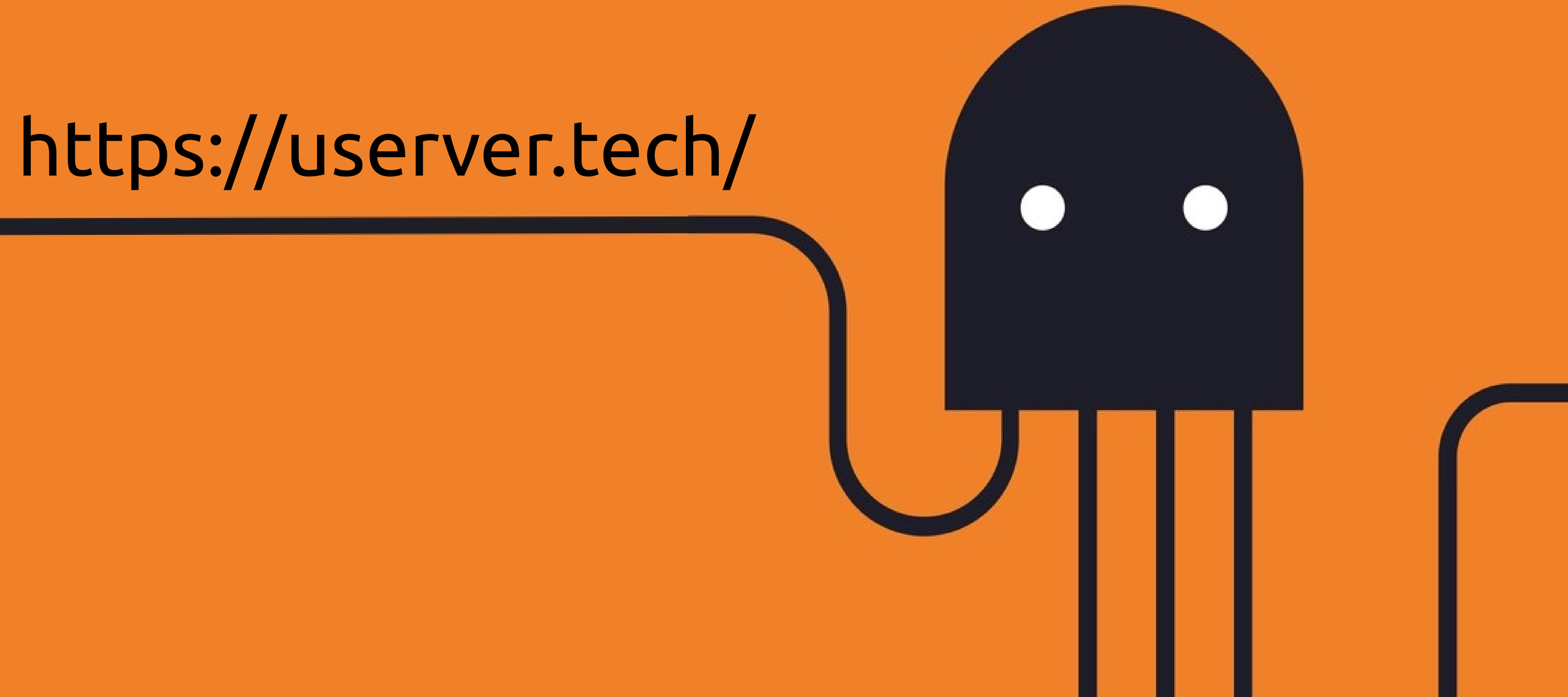
C++

- Frightens fragile minds ✠:-)

So we made our own framework

https://userver.tech/



Callback Hell

Callback Hell

```
void View::Handle(Request&& request, const Dependencies& dependencies, Response
response) {
  dependencies.pg->GetCluster(
    [request = std::move(request), response](auto cluster)
  {
    cluster->Begin(storages::postgres::ClusterHostType::kMaster,
      [request = std::move(request), response](auto& trx)
    {
      const char* statement = "SELECT ok, baz FROM some WHERE id = $1 LIMIT 1";
      psql::Execute(trx, statement, request.id,
        [request = std::move(request), response, trx = std::move(trx)](auto& res)
      {
        auto row = res[0];
        if (!row["ok"].As<bool>()) {
          if (LogDebug()) {
              GetSomeInfoFromDb([id = request.id](auto info) {
                  LOG_DEBUG() << id << " is not OK of " << info;
              });
```

Callback Hell

```
            }
            *response = Response400{};
          }
          psql::Execute(trx, queries::kUpdateRules, request.foo, request.bar,
            [row = std::move(row), trx = std::move(trx), response]()
          {
            trx.Commit([row = std::move(row), response]() {
              *response = Response200{row["baz"].As<std::string>()};
            });
          });
        });
      });
    });
  }
```

Callback Hell

~~Callback Hell~~ Coroutines

Coroutines

```
Response View::Handle(Request&& request, const Dependencies& dependencies) {
  auto cluster = co_await dependencies.pg->GetCluster();

  auto trx = co_await cluster->Begin(postgres::ClusterHostType::kMaster);

  const char* statement = "SELECT ok, baz FROM some WHERE id = $1 LIMIT 1";
  auto row = co_await psql::Execute(trx, statement, request.id)[0];
  if (!row["ok"].As<bool>()) {
    LOG_DEBUG() << request.id << " is not OK of "
                << co_await GetSomeInfoFromDb();
    return Response400();
  }

  co_await psql::Execute(trx, queries::kUpdateRules, request.foo, request.bar);
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It’s 2017

It’s 2017 – C++ does not have coroutines

Stackless Coroutines

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Experiments

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New functionality

For example, we plan to introduce the new functionality «payed roads»

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- Code is written

New functionality

For example, we plan to introduce the new functionality «payed roads»

- Code is written
- Code is tested

New functionality

For example, we plan to introduce the new functionality «payed roads»

- Code is written
- Code is tested
- It breaks in production

What to do?

Wrong solutions

Wrong solutions

- Fix the code and redeploy

Wrong solutions

- Fix the code and redeploy
- Or change the configuration files and redeploy

The Right Solution

The Right Solution – Dynamic Configs

The Right Solution

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Service that distributes configs

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Service that distributes configs:

- Change the config value from the browser

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- Experiments

The Right Solution

Service that distributes configs:

- Change the config value from the browser
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Features:

- Safe deployment of a new functionality
- Experiments
- Limits/timeouts/log levels/degradation…

Dynamic Configs

```
int Component::DoSomething() const {
  const auto runtime_config = config_.GetSnapshot();
  return runtime_config[kMyConfig];
}
```

Dynamic Configs

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int Component::DoSomething() const {
  const auto runtime_config = config_.GetSnapshot();
  return runtime_config[kMyConfig];
}
```

Dynamic Configs

```
int Component::DoSomething() const {
  const auto runtime_config = config_.GetSnapshot();
  return runtime_config[kMyConfig];
}
```

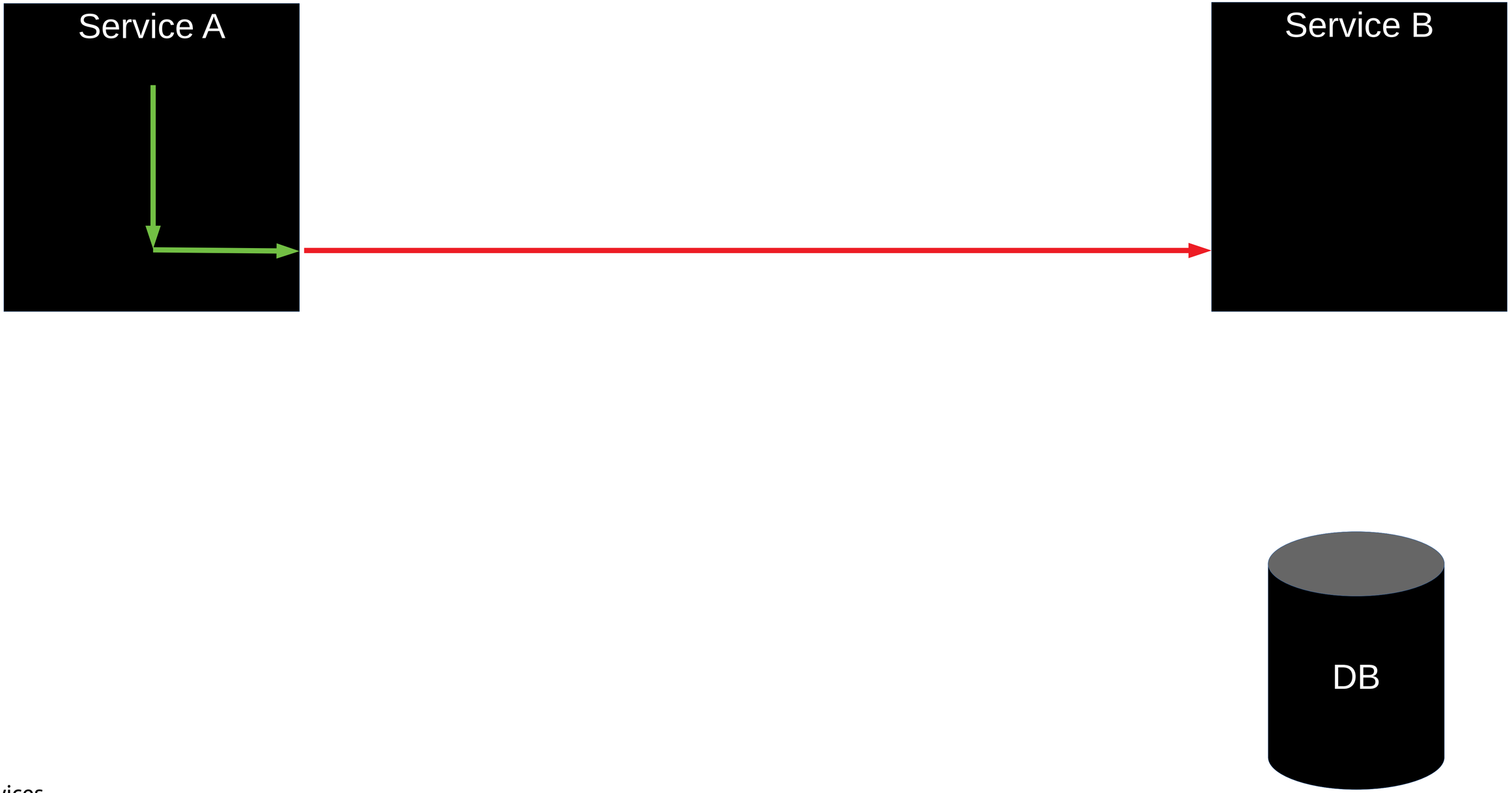
Latency

A Request

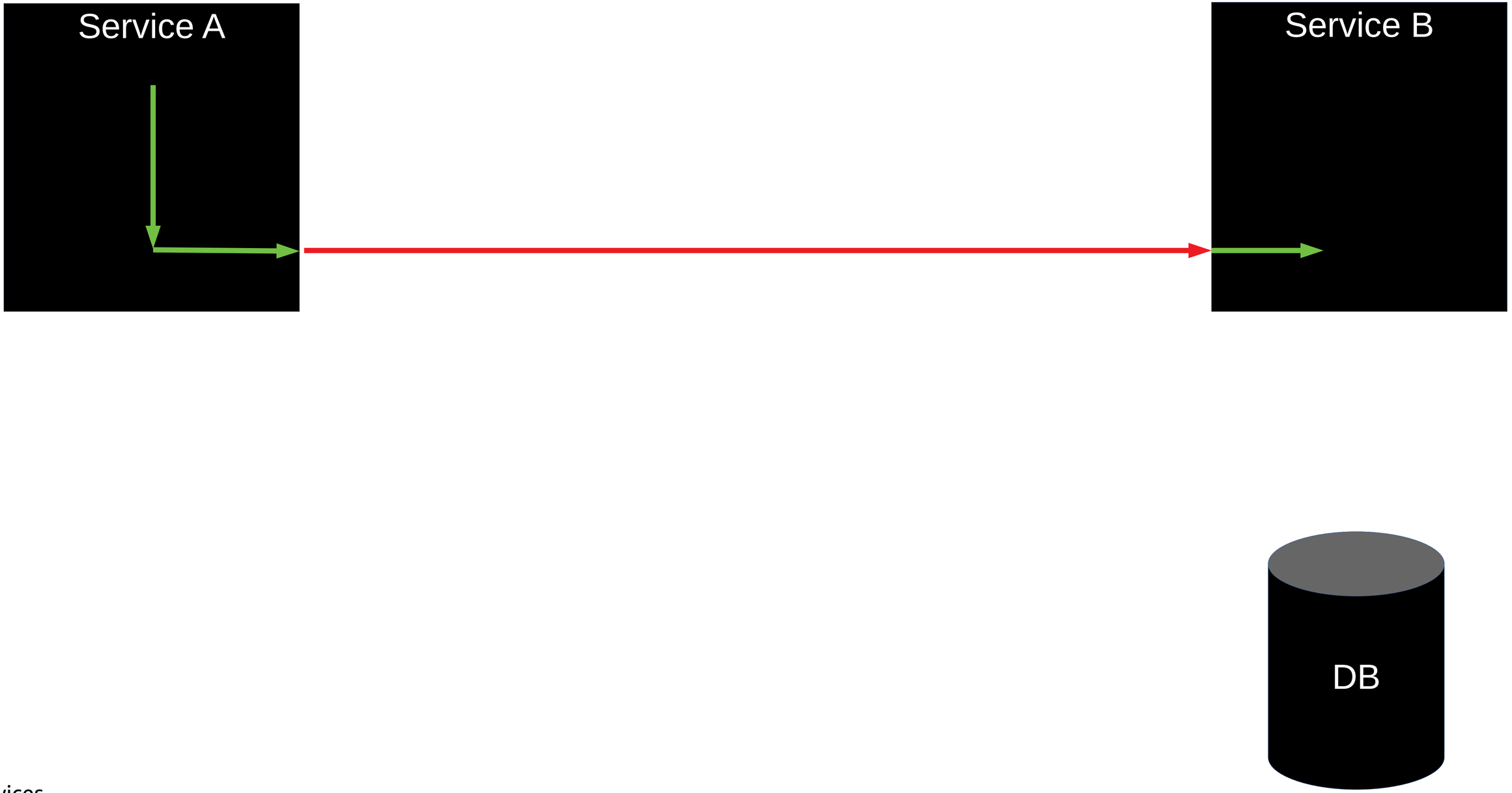
A Request

A Request

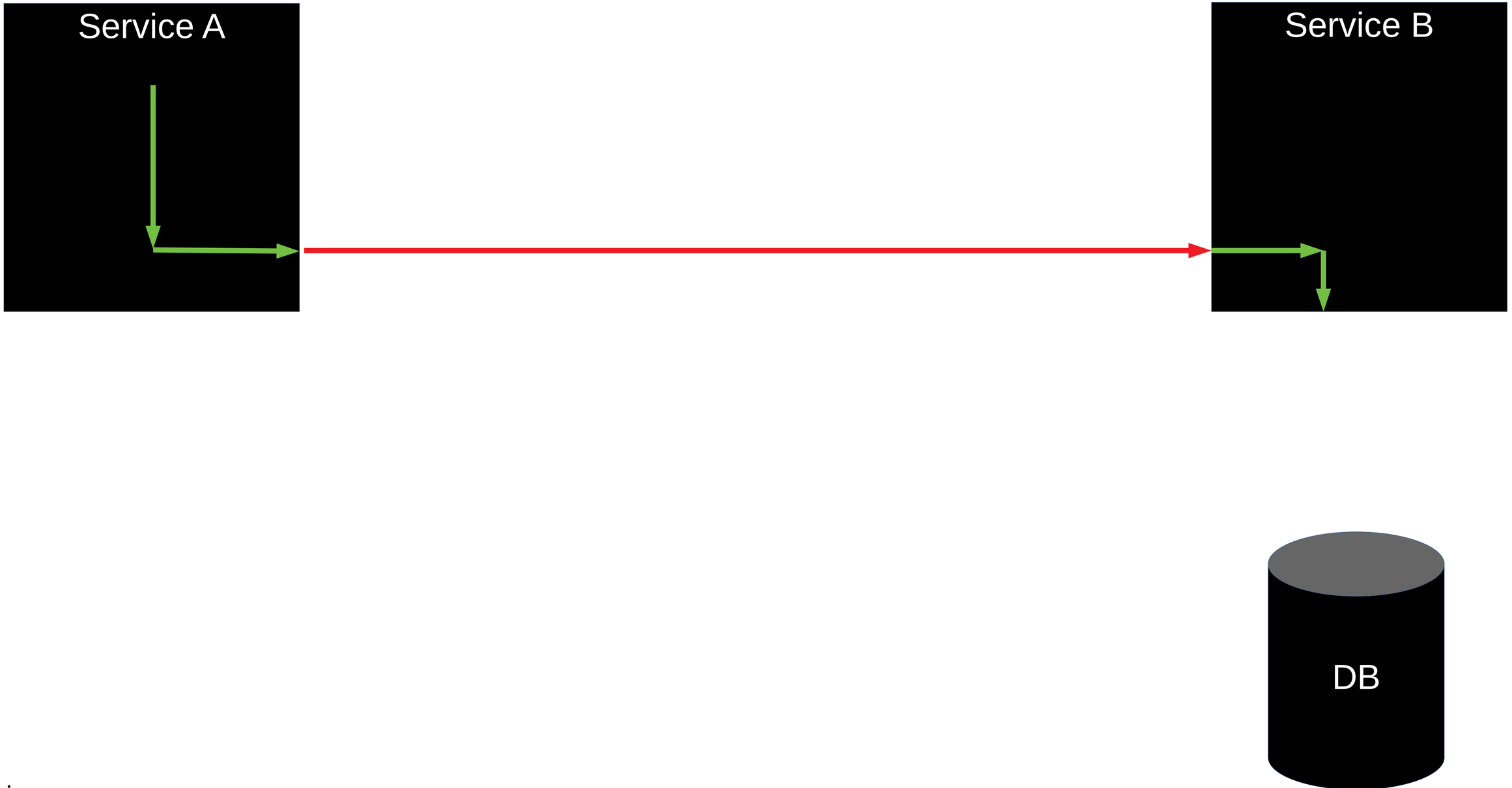
A Request



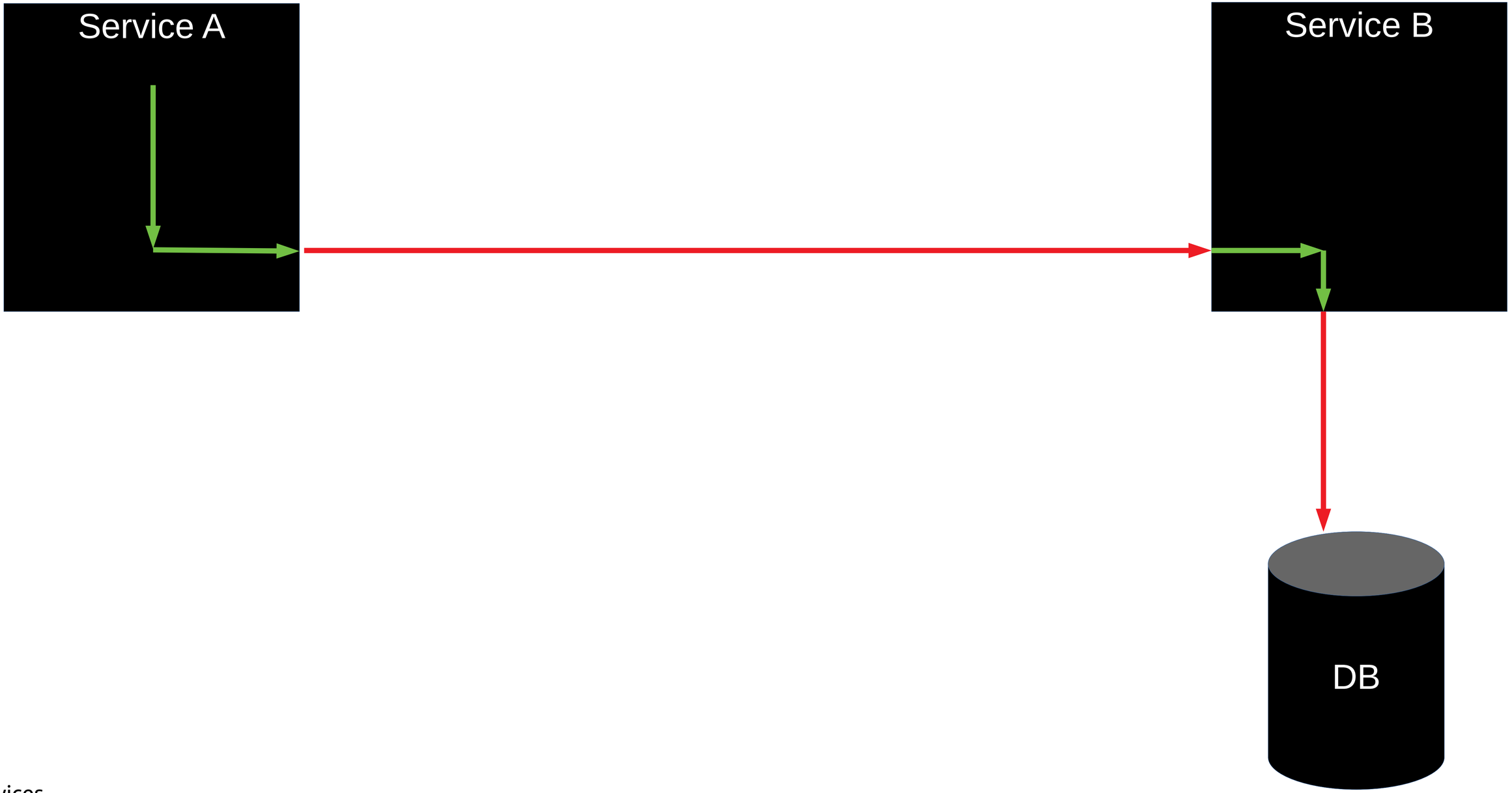
A Request



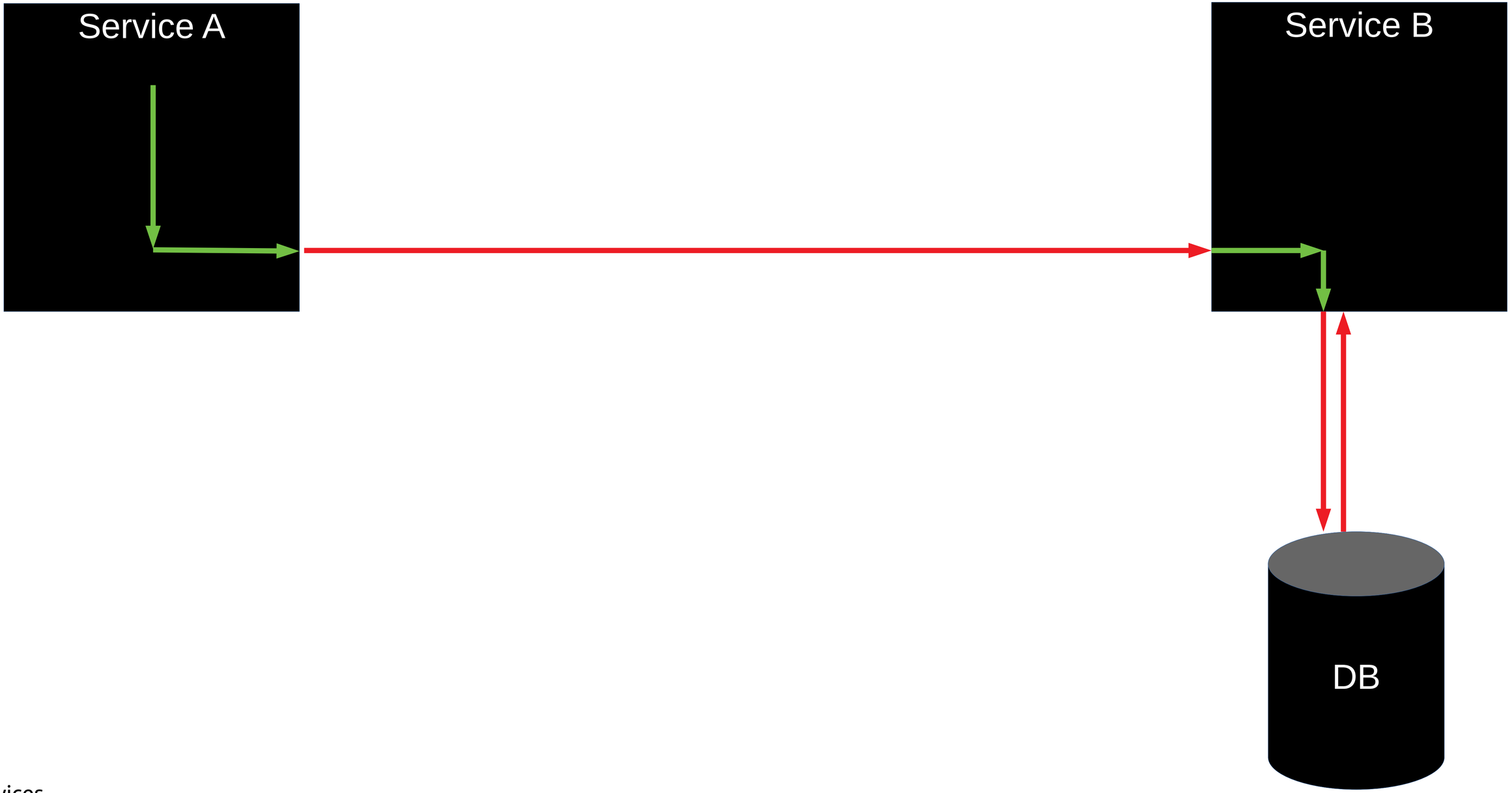
A Request



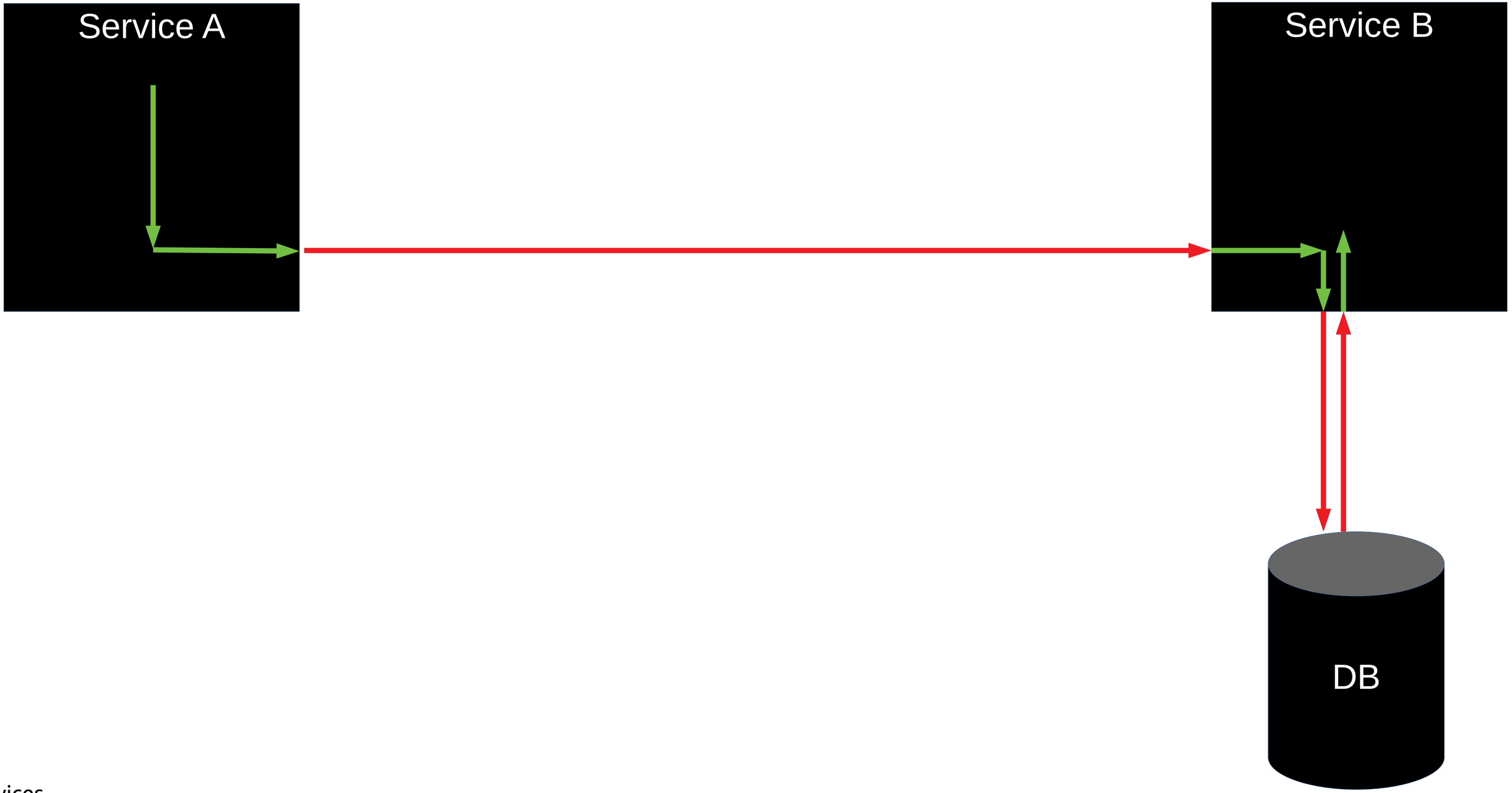
A Request



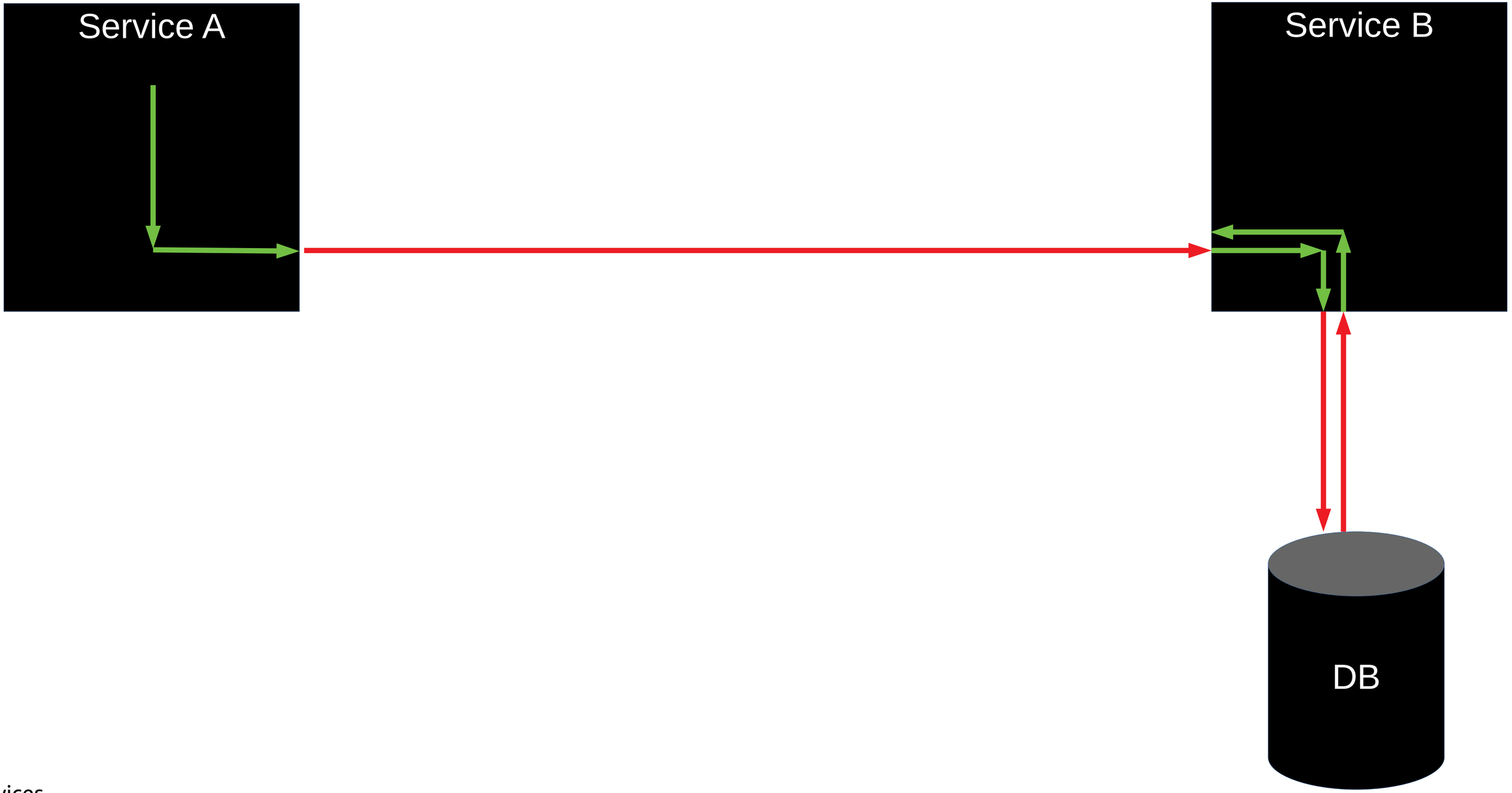
A Request



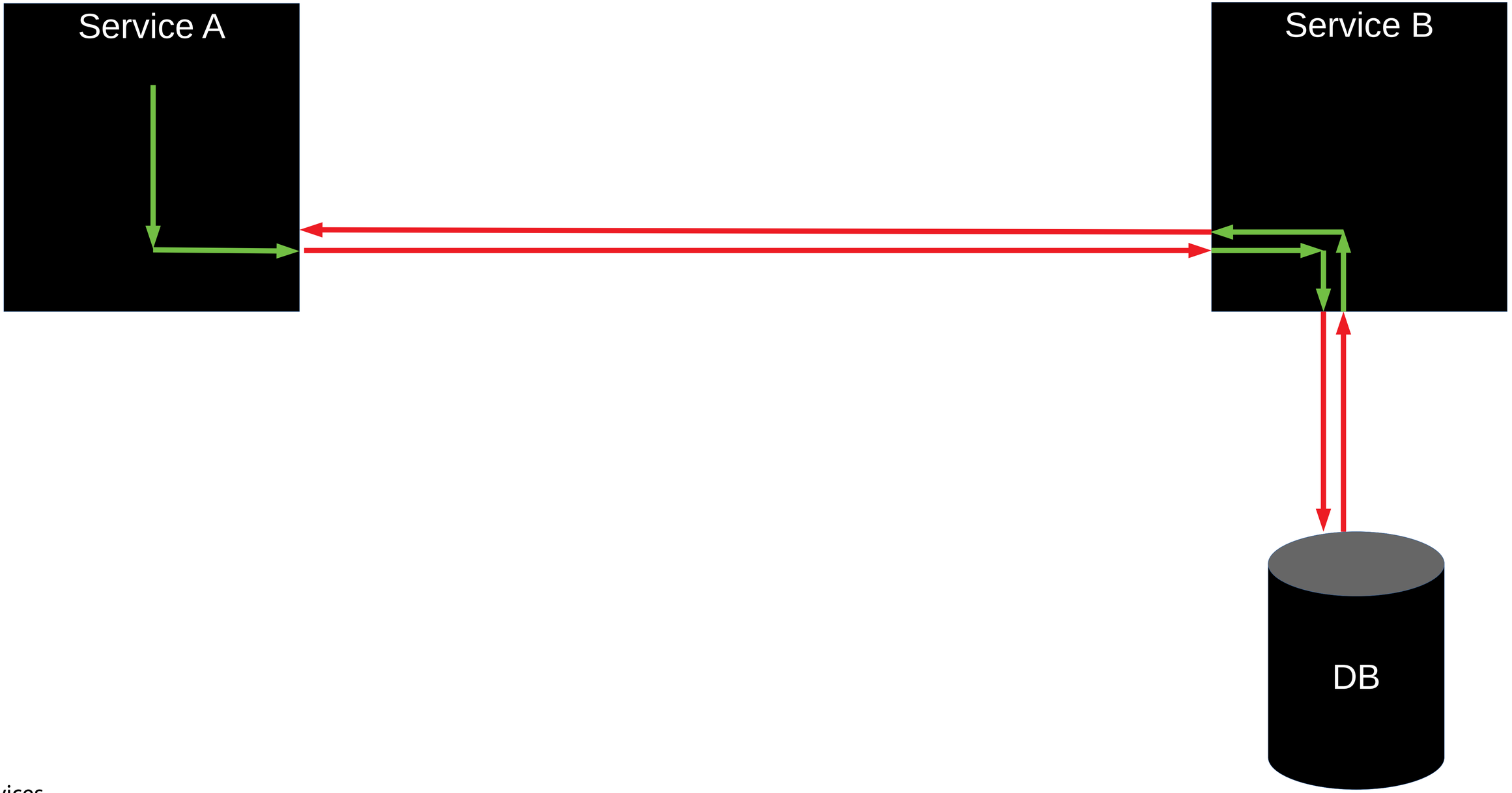
A Request



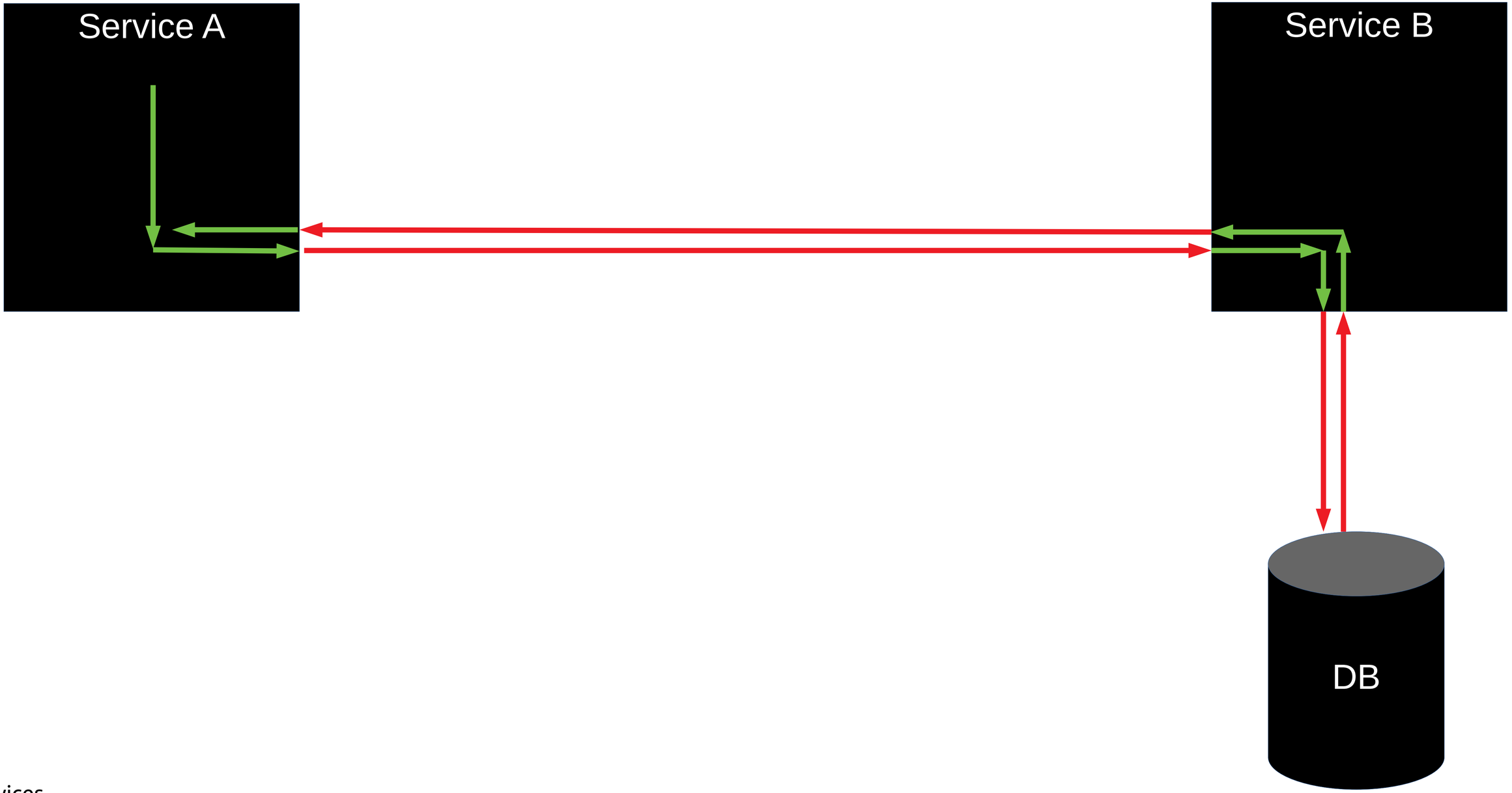
A Request



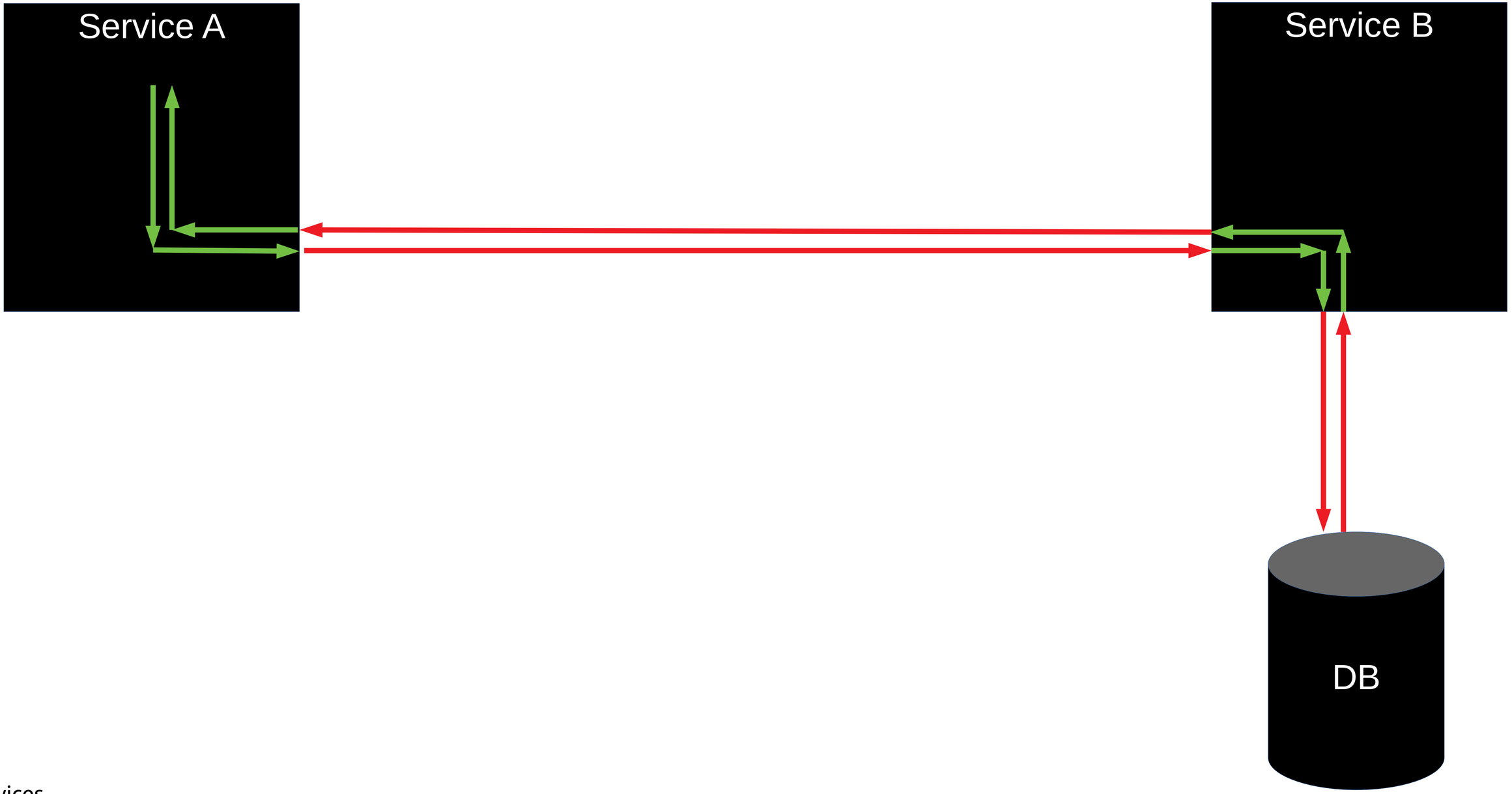
A Request



A Request

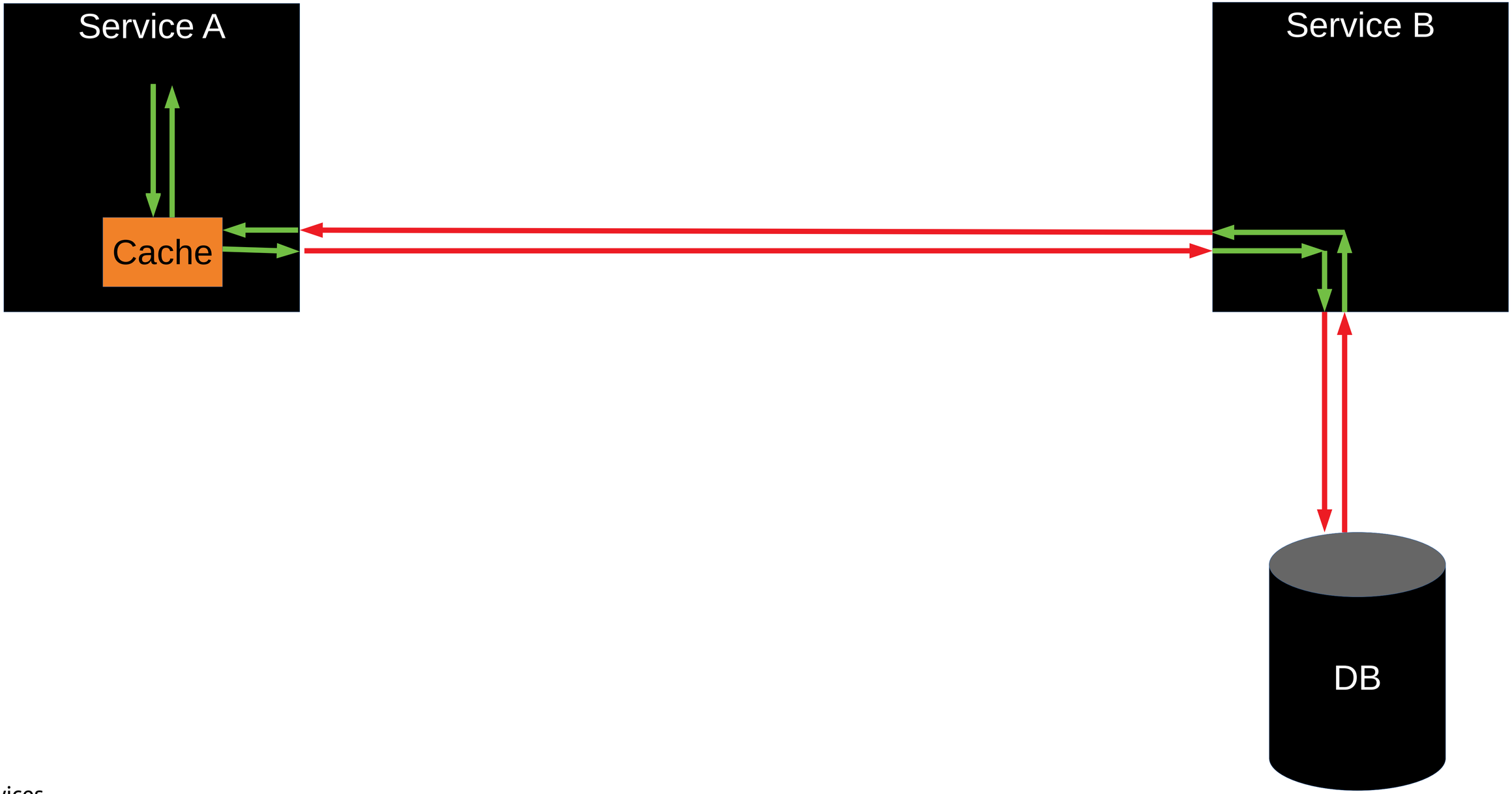


A Request



~~Latency~~ Caches

Cache



Cache

Cache

Cache

All Sorts of Caches

All Sorts of Caches

- components::PostgreCache< PostgreCachePolicy >

Postgre Cache Policy

```
struct AssortmentTraitCachePolicy {
  static constexpr std::string_view kName = "assortment-trait-cache";

  using ValueType = Assortment;
  static constexpr auto kKeyMember = &Assortment::item_id;
  static const storages::postgres::Query kQuery = "SELECT a, b, c FROM table";
  static constexpr auto kUpdatedField = "update_time";
  using UpdatedFieldType = storages::postgres::TimePointTz;
};

using AssortmentCache = components::PostgreCache<AssortmentTraitCachePolicy>;
```

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```

All Sorts of Caches

- components::PostgreCache< PostgreCachePolicy >

All Sorts of Caches

- components::PostgreCache< PostgreCachePolicy >
- components::MongoCache< MongoCacheTraits >

All Sorts of Caches

- components::PostgreCache< PostgreCachePolicy >
- components::MongoCache< MongoCacheTraits >
- components::CachingComponentBase

All Sorts of Caches

- components::PostgreCache< PostgreCachePolicy >
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- LRU

All Sorts of Caches

- components::PostgreCache< PostgreCachePolicy >
- components::MongoCache< MongoCacheTraits >
- components::CachingComponentBase

- LRU:
  - cache::LruCacheComponent< Key, Value, Hash, Equal >

All Sorts of Caches

- components::PostgreCache< PostgreCachePolicy >
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- LRU:
  - cache::LruCacheComponent< Key, Value, Hash, Equal >
  - cache::ExpirableLruCache< Key, Value, Hash, Equal >

All Sorts of Caches

- components::PostgreCache< PostgreCachePolicy >
- components::MongoCache< MongoCacheTraits >
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- LRU:
  - cache::LruCacheComponent< Key, Value, Hash, Equal >
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- Containers

All Sorts of Caches

- components::PostgreCache< PostgreCachePolicy >
- components::MongoCache< MongoCacheTraits >
- components::CachingComponentBase

- LRU:
  - cache::LruCacheComponent< Key, Value, Hash, Equal >
  - cache::ExpirableLruCache< Key, Value, Hash, Equal >

- Containers:
  - cache::NWayLRU< T, U, Hash, Equal >
  - cache::LruMap< T, U, Hash, Equal >
  - cache::LruSet< T, Hash, Equal >

C++ scares

C++ ~~scares~~ aids

Feedback

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«I’m a C# developer. I had no idea that coding in C++ is easy»

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«No matter how unbelievable it sounds…

Feedback

«I’m a C# developer. I had no idea that coding in C++ is easy»

«No matter how unbelievable it sounds…
...it really doesn’t take much longer to write services on **userver** than on Python»

RAII

C++ Hello World

```
char* get1();
char* get2();
void do_something(const char* s);
```

C++ Hello World

```
char* get1();
char* get2();
void do_something(const char* s);

char* str_plus(const char* s1, const char* s2) {




}
```

C++ Hello World

```
char* get1();
char* get2();
void do_something(const char* s);

char* str_plus(const char* s1, const char* s2) {
    unsigned len = strlen(s1) + strlen(s2) + 1;




}
```

C++ Hello World

```
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char* get1();
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void do_something(const char* s);

char* str_plus(const char* s1, const char* s2) {
    unsigned len = strlen(s1) + strlen(s2) + 1;
    char* result = (char*)malloc(len);



}
```

C++ Hello World

```
char* get1();
char* get2();
void do_something(const char* s);

char* str_plus(const char* s1, const char* s2) {
    unsigned len = strlen(s1) + strlen(s2) + 1;
    char* result = (char*)malloc(len);
    strcat(result, s1);
    strcat(result, s2);

}
```

C++ Hello World

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char* get1();
char* get2();
void do_something(const char* s);

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    return result;
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    strcat(result, s1);
    strcat(result, s2);
    return result;
}

void example1() {









}
```

C++ Hello World

```
char* get1();
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void do_something(const char* s);

char* str_plus(const char* s1, const char* s2) {
    unsigned len = strlen(s1) + strlen(s2) + 1;
    char* result = (char*)malloc(len);
    strcat(result, s1);
    strcat(result, s2);
    return result;
}

void example1() {
    char *s1 = get1(), *s2 = get2();









}
```

C++ Hello World

```
char* get1();
char* get2();
void do_something(const char* s);

char* str_plus(const char* s1, const char* s2) {
    unsigned len = strlen(s1) + strlen(s2) + 1;
    char* result = (char*)malloc(len);
    strcat(result, s1);
    strcat(result, s2);
    return result;
}

void example1() {
    char *s1 = get1(), *s2 = get2();
    char* result = str_plus(s1, s2);




}
```

C++ Hello World

```
char* get1();
char* get2();
void do_something(const char* s);

char* str_plus(const char* s1, const char* s2) {
    unsigned len = strlen(s1) + strlen(s2) + 1;
    char* result = (char*)malloc(len);
    strcat(result, s1);
    strcat(result, s2);
    return result;
}

void example1() {
    char *s1 = get1(), *s2 = get2();
    char* result = str_plus(s1, s2);
    do_something(result);



}
```

C++ Hello World

```
char* get1();
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void do_something(const char* s);

char* str_plus(const char* s1, const char* s2) {
    unsigned len = strlen(s1) + strlen(s2) + 1;
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    return result;
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void example1() {
    char *s1 = get1(), *s2 = get2();
    char* result = str_plus(s1, s2);
    do_something(result);
    free(result);



}
```

C++ Hello World

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char* get1();
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void do_something(const char* s);

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    unsigned len = strlen(s1) + strlen(s2) + 1;
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    strcat(result, s1);
    strcat(result, s2);
    return result;
}

void example1() {
    char *s1 = get1(), *s2 = get2();
    char* result = str_plus(s1, s2);
    do_something(result);
    free(result);
    // free(s1); ???
    // free(s2); ???
}
```

That was not a C++ code!!!

Here’s a C++ code:

C++ Hello World

```
std::string get_str1();
std::string get_str2();
void do_something(const char* s);

void example2() {
    auto result = get_str1() + get_str2();
    do_something(result.c_str());
}
```

C++ Hello World

```
std::string get_str1();
std::string get_str2();
void do_something(const char* s);

void example2() {
    auto result = get_str1() + get_str2();
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}
```

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std::string get_str1();
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    auto result = get_str1() + get_str2();
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}
```

RAII

RAII, -Wall

RAII, -Wall, sanitizers

RAII, -Wall, sanitizers, clang-tidy

RAII, -Wall, sanitizers, clang-tidy, asserts

Compile Time is your friend!

Catching Bugs at Compile Time

Catching Bugs at Compile Time

```
const auto& name = cache.Get()->name;
```

Catching Bugs at Compile Time

```
const auto& name = cache.Get()->name;
DoSomething(name);
```

Catching Bugs at Compile Time

```
const auto& name = cache.Get()->name;
DoSomething(name);
```

```
// const auto& name = cache.Get()->name;
//                    ~~~~~~~~~~^
// error: keep the pointer before using, please
```

SharedReadablePtr

utils::SharedReadablePtr< T >	**Get** () const
utils::SharedReadablePtr< T >	**GetUnsafe** () const

SharedReadablePtr

const T &	**operator*** () const &noexcept
const T &	**operator*** () &&
const T *	**operator->** () const &noexcept
const T *	**operator->** () &&

Catching Bugs at Compile Time

```
const auto& name = cache.Get()->name;
DoSomething(name);
```

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// const auto& name = cache.Get()->name;
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Catching Bugs at Compile Time

```
const auto& name = cache.Get()->name;
DoSomething(name);
```

```
// const auto& name = cache.Get()->name;
//                    ~~~~~~~~~~^
// error: keep the pointer before using, please
```

static_assert

static_assert everything

```
template <typename T>
T Value::As() const {

  static_assert(formats::common::kHasParseTo<Value, T>,
                "There is no `Parse(const Value&, formats::parse::To<T>)` "
                "in namespace of `T` or `formats::parse`. "
                "Probably you forgot to include the "
                "<formats/parse/common_containers.hpp> or you "
                "have not provided a `Parse` function overload.");

  return Parse(*this, formats::parse::To<T>{});
}
```

static_assert everything

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                "There is no `Parse(const Value&, formats::parse::To<T>)` "
                "in namespace of `T` or `formats::parse`. "
                "Probably you forgot to include the "
                "<formats/parse/common_containers.hpp> or you "
                "have not provided a `Parse` function overload.");

  return Parse(*this, formats::parse::To<T>{});
}
```

Modern C++

Modern C++17

C++17

C++17

- std::optional

C++17

- std::optional
- std::variant

C++17

- std::optional
- std::variant
- [[nodiscard]]

C++17

- std::optional
- std::variant
- [[nodiscard]]
- std::string_view

C++17

- std::optional
- std::variant
- [[nodiscard]]
- std::string_view
- guaranteed copy elision

C++17

- std::optional
- std::variant
- [[nodiscard]]
- std::string_view
- guaranteed copy elision
- if constexpr

Testsuite +

Tests

```
async def test_ping(service_client):
    response = await service_client.get('/hello')
    assert response.status == 200
    assert response.content == b'Hello world!\n'
```

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The Result

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- Efficiency

The Result

- Efficiency → C++ & async IO

The Result

- Efficiency → C++ & async IO
- Simplicity of development

The Result

- Efficiency → C++ & async IO
- Simplicity of development → microservices & stackfull coroutines

The Result

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- Simplicity of development → microservices & stackfull coroutines
- High development speed

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- High development speed → testsuite & compile time & ready solutions

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- Safety

The Result

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- High development speed → testsuite & compile time & ready solutions
- Safety → compile time & Yandex scale tested tools

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- Efficiency → C++ & async IO
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Solutions

The Result

- Efficiency → C++ & async IO
- Simplicity of development → microservices & stackfull coroutines
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- Latencies

The Result

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Solutions:

- Latencies → caches

The Result

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Solutions:

- Latencies → caches
- C++ scares

The Result

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- Scalability → microservices

Solutions:

- Latencies → caches
- C++ scares → well designed solutions

The Result

- Efficiency → C++ & async IO
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- Safety → compile time & Yandex scale tested tools
- Scalability → microservices

Solutions:

- Latencies → caches
- C++ scares → well designed solutions
- Databases

The Result

- Efficiency → C++ & async IO
- Simplicity of development → microservices & stackfull coroutines
- High development speed → testsuite & compile time & ready solutions
- Safety → compile time & Yandex scale tested tools
- Scalability → microservices

Solutions:

- Latencies → caches
- C++ scares → well designed solutions
- Databases, Dynamic configs

The Result

- Efficiency → C++ & async IO
- Simplicity of development → microservices & stackfull coroutines
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Solutions:

- Latencies → caches
- C++ scares → well designed solutions
- Databases, Dynamic configs, Tracing

The Result

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Solutions:

- Latencies → caches
- C++ scares → well designed solutions
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Solutions:

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- C++ scares → well designed solutions
- Databases, Dynamic configs, Tracing, Metrics, Deadlines

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Solutions:

- Latencies → caches
- C++ scares → well designed solutions
- Databases, Dynamic configs, Tracing, Metrics, Deadlines, Distlocks
- ...

Thanks for watching!

Antony Polukhin

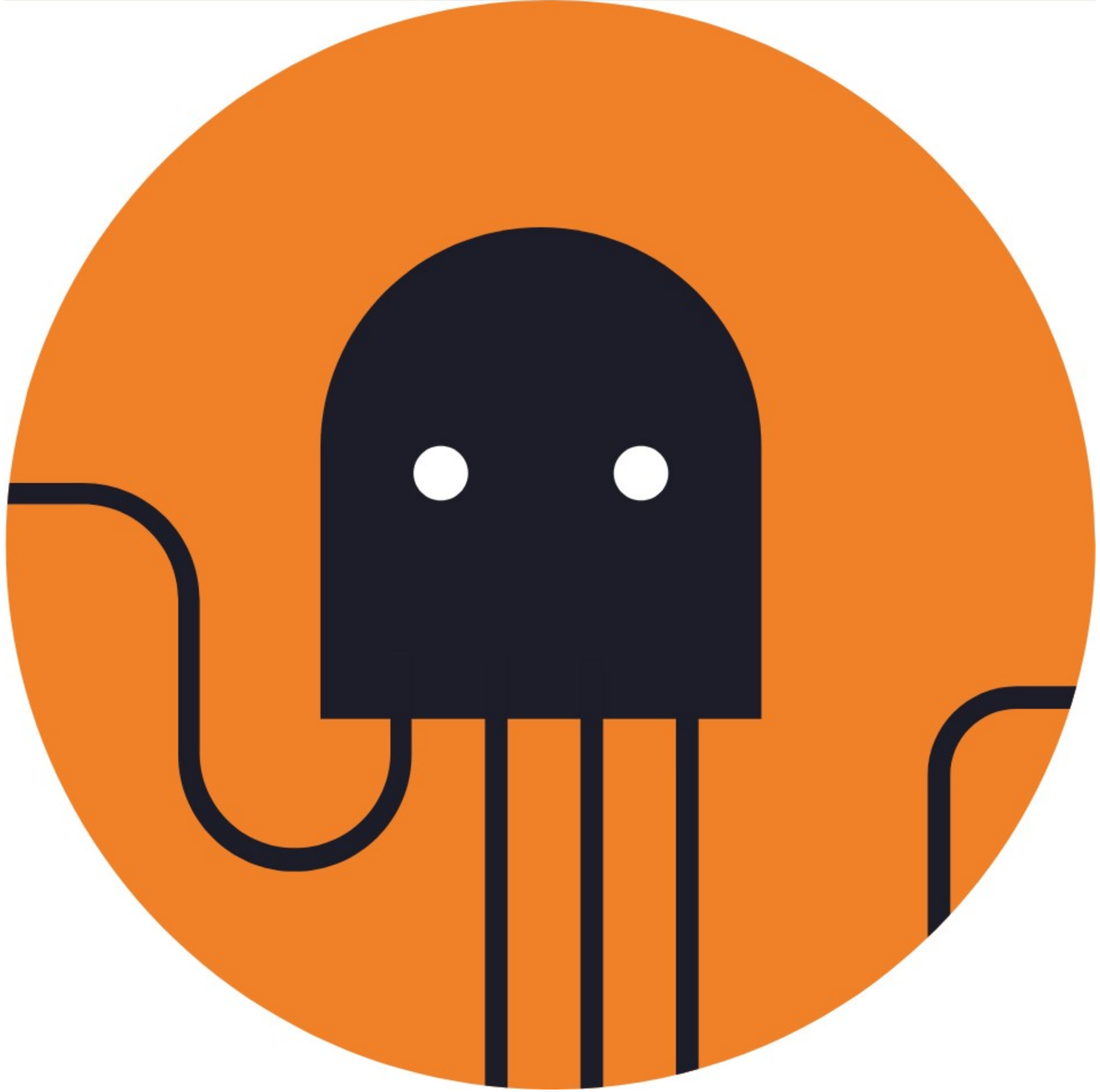
C++ Expert developer, Team Lead

antoshkka@gmail.com

antoshkka@yandex-team.ru

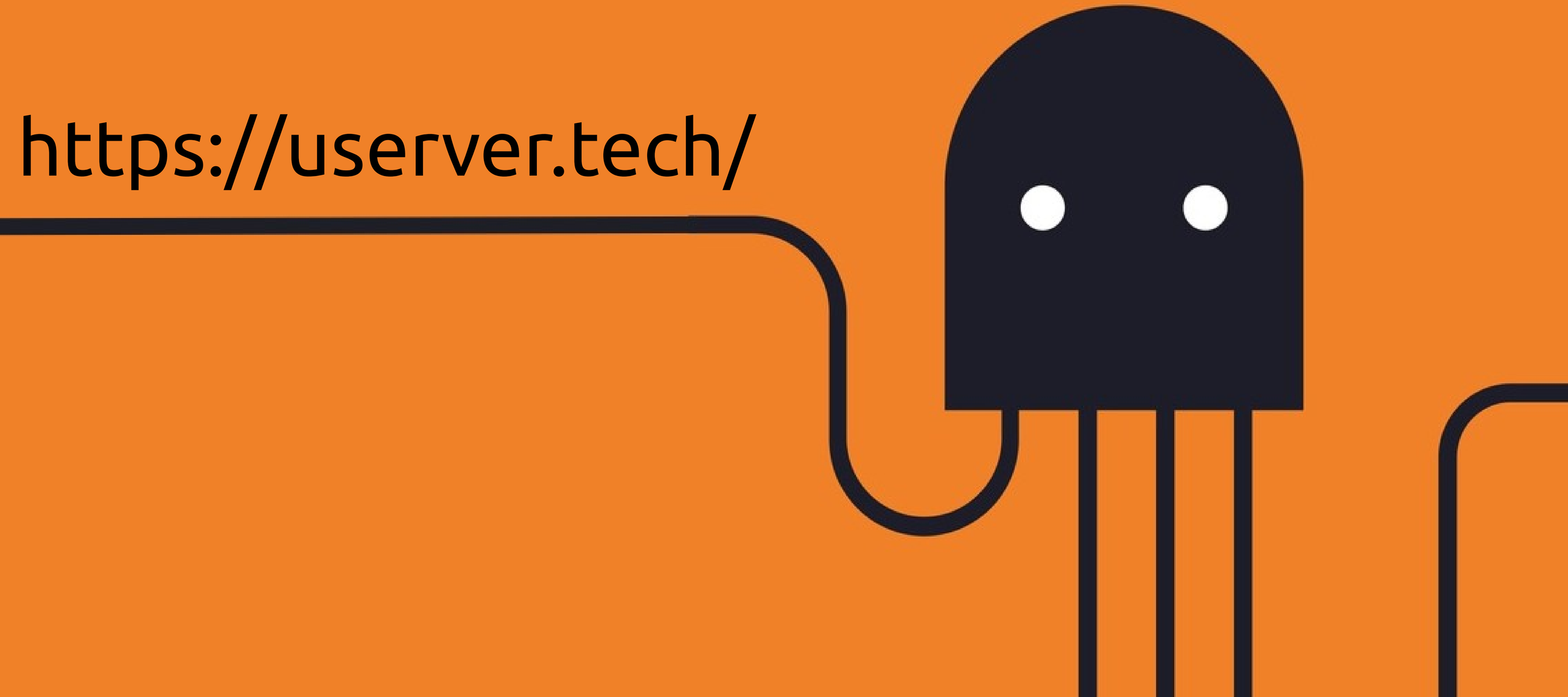
https://github.com/apolukhin

https://stdcpp.ru/



https://github.com/userver-framework

https://userver.tech/



Leave your feedback!

You can rate the talk and give a feedback on what you've liked or what could be improved

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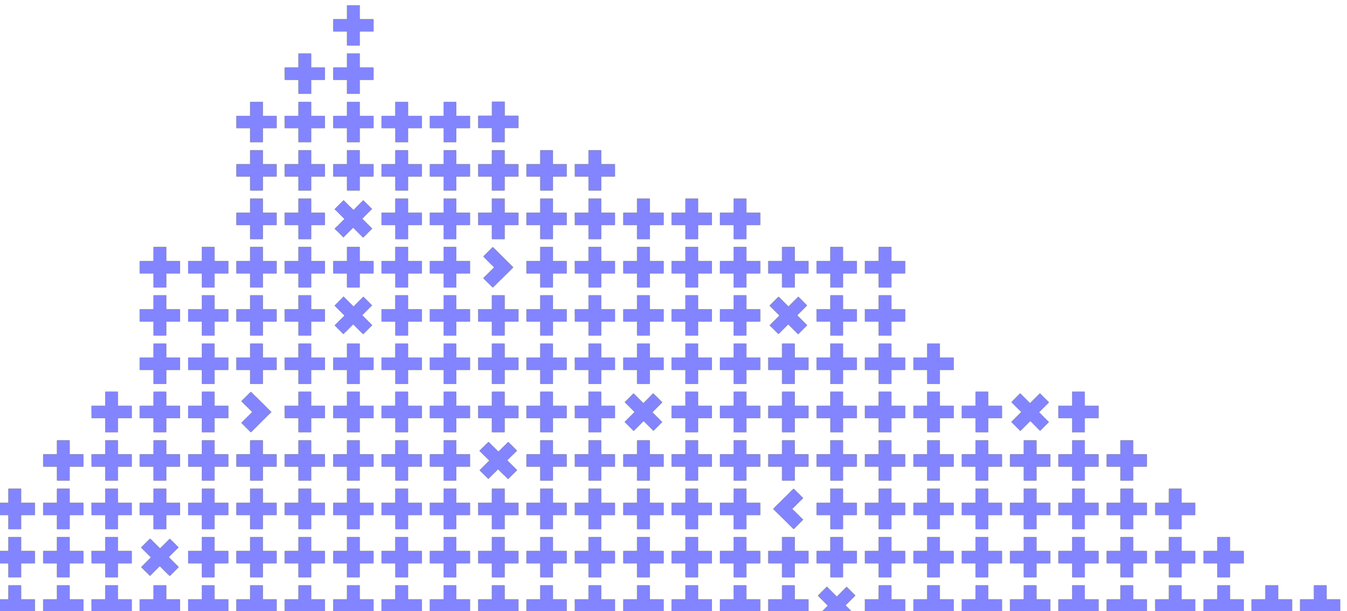

Co-organizer

Yandex